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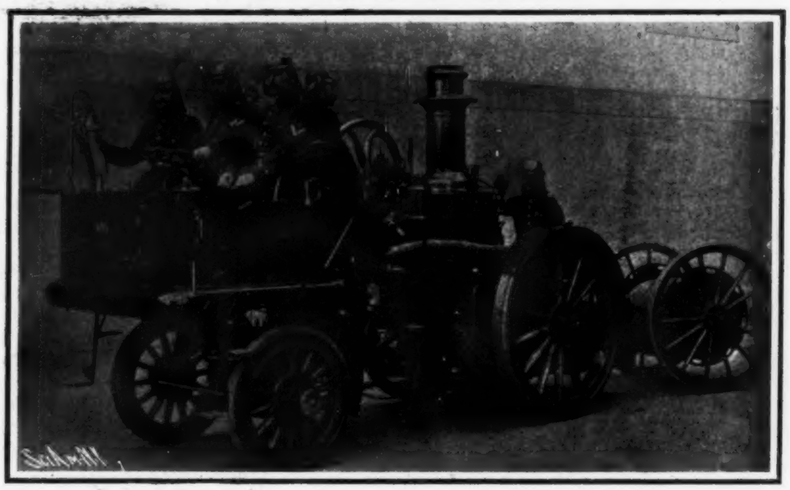
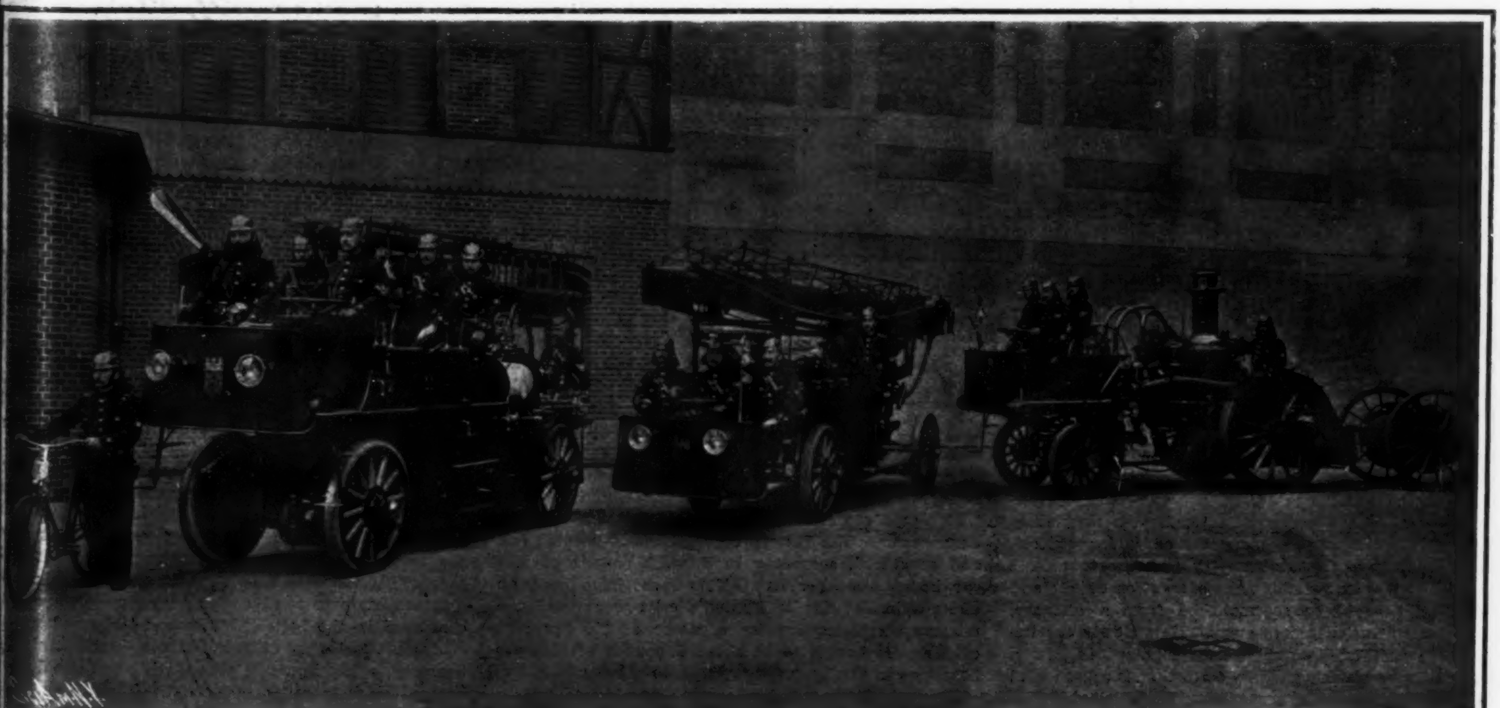
THE EXTENSION LADDER IN SERVICE.

THE MOTOR DRIVEN LADDER TRUCK.



THE STEAM-OPERATED AUTOMOBILE FIRE ENGINE.



THE TRAIN OF FIRE-FIGHTING APPARATUS READY TO START.

AN UP-TO-DATE GERMAN FIRE BRIGADE STATION.

AN UP-TO-DATE GERMAN FIRE BRIGADE.

THE MOST REMARKABLE STATION IN THE WORLD.

BY DR. ALFRED GRADENWITZ.

THE writer a short time ago had an opportunity of inspecting the fire brigade station of the city of Schöneberg, near Berlin, which is one of the most remarkable fire stations in the world. The fire alarms, which are installed at all the more important and frequented places, are readily visible by day, owing to their bright red coloring, and by night by a red signal lamp. After breaking the glass plate the handle of the alarm is operated, actuating a bell situated in the interior of the apparatus, which draws the attention of the public and of any policemen near at hand to the fire alarm, thus rendering any wanton use of the bell practically impossible. The location of the alarm is automatically signaled to the telegraph room of the fire brigade station, so that the brigade may be sent to the scene of action immediately.

One of the most remarkable features of the Schöneberg fire brigade station is the exclusive use of complete automobile fire trains. As seen in one of the illustrations, each train comprises three motor cars, two of which are driven by electricity and one by steam. Steam was given the preference in the case of the third car, in order to use the same agent at the fire. The boiler of the latter car is kept permanently under a working pressure of five to six atmospheres, and accordingly is ready to start out at a moment's notice. The maximum speed of this machine is 18 to 22 miles per hour.

Apart from the higher speed afforded by motor cars as compared with horse-drawn apparatus, a considerable saving is insured, as the space requirements of automobiles are far less than those of horse-drawn trucks, while operations are carried out with a smaller crew. These advantages as well as the greater economy of operation make up for the higher first cost of the automobile apparatus.

The leading car of the train is a gas-operated fire engine, provided with a vertical cylinder of about 120 gallons capacity, fitted between the rear wheels. The water contained in this cylinder is forced out by carbonic acid gas, and is immediately used on arriving at the fire while the hose is being coupled to the hydrants. When the municipal water supply proves insufficient to feed the hose, the steam-operated fire engine is resorted to. This engine is designed for an output of about 2,000 liters (528.4 gallons) per minute. Kerosene stored in three reservoirs is used as fuel. It is forced by carbonic acid into a special vaporizer which gasifies it and enables it to be burned in a suitable burner without smoke or soot.

The gas-operated fire engine is used also as a supply car, and carries extra hose, ladders which may be extended to a height of 40 feet, life nets, respiratory apparatus, fire safeguards, bandages, and all kinds of tools. An interesting novelty is the direction indicator, consisting of a semaphore which by night is lighted by electricity. The position of the semaphore represented in the engraving shows that the train will turn to the right at the next crossing. If the train was to travel straight ahead, the gage would be kept permanently vertical.

The ladder truck carries an extension ladder of improved type. It comprises four sections folded above one another, and is operated by the aid of an electric motor located in the turret. A carbonic-acid engine is used to extend or fold the ladder. The ladder can be raised in 20 to 30 seconds. It is provided with a railing at each side, so that victims of the fire, unless overcome or helpless, may climb down the ladder without any danger.

The firemen always carry ropes with them, for use in lowering persons from the windows when necessary. The life net used by the Schöneberg fire brigade station is of American origin, and has so far been introduced only sparingly on the other side of the ocean.

The writer is indebted to Fire Inspector Meyer for courtesies extended to him in preparing this article.

THE HISTORY OF ELECTRIC MOTIVE POWER.*

A BRIEF RECORD OF RAPID DEVELOPMENT.

BY PROF. SILVANUS P. THOMPSON.

IN 1821 Faraday, after studying the phenomena of electromagnetic deflection of a needle by an electric current (Oersted's discovery), first succeeded in producing continuous rotations by electromagnetic means. In his simple apparatus a piece of suspended copper wire, carrying a current from a small battery, and dipping at its lower end into a cup of mercury, rotated continuously around the pole of a short bar-magnet of steel placed upright in the cup. In another variety of this experiment the magnet rotated around the central wire, which was fixed. These pieces of apparatus were the merest toys, incapable of doing any useful work; nevertheless they demonstrated the essential principle, and suggested further possibilities. Two years later, Barlow, using a star-wheel of copper, pivoted so that the lowest point of the star should make contact with a small pool of mercury, found that the star-wheel rotated if a current was sent through the arm of the star while the arm itself was situated between the poles of a steel horseshoe-magnet. Shortly afterward Sturgeon improved the apparatus by substituting a copper disk for the star-wheel. The action was the same. A conductor, carrying an electric current, if placed in a magnetic field, is found to experience a mechanical drag, which is neither an attraction nor a repulsion, but a lateral force tending to move it at right angles to the direction of flow of the current and at right angles to the direction of the lines of the magnetic field in which it is situated. Still this was a toy. Two years later came the announcement by Sturgeon of the invention of the soft-iron electromagnet, one of the most momentous of all inventions, since upon it practically the whole of the constructive part of electrical engineering is based. For the first time mankind was furnished with a magnet the attractive power of which could be increased absolutely indefinitely by the mere expenditure of sufficient capital upon the iron core and its surrounding copper coils, and the provision of a sufficiently powerful source of electric current to excite the magnetization. Furthermore the magnet was under control, and could be made to attract or to cease to attract at will by merely switching the current on or off; and lastly, this could be accomplished from a distance, even from great distances away. How slowly the importance of this discovery was recognized is now a matter for astonishment. To state that Sturgeon died in poverty twenty-six years later is sufficient to indicate his place among the unrequited pioneers of whom the world is not worthy. Six years elapsed, and then there came a flood of suggestions of electric motors in which was applied the principle of intermittent attraction by an electromagnet. Henry in 1831 and Dal Negro in 1832 produced see-saw mechanisms so operated. Ritchie in 1833 and Jacobi in 1834 devised rotatory motors. Ritchie pivoted a rapidly commutated electromagnet between the poles of a permanent magnet—a true type of the modern motor—while Jacobi caused two multipolar electromagnets, one fixed, one movable, to put a shaft into rotation and propel a boat. A perplexing diminution of the current of the battery whenever the motor was running caused Jacobi to investigate mathematically the theory of its action. In a masterly memoir he laid down a few years later the theory of electric motive power. But in the intervening period, in 1831, Faraday had made the cardinal discovery of the mechanical generation of electric currents by magneto-electric induction, the fundamental principle of the dynamo. Down to that date the only known way—save for the feeble currents of thermopiles—to generate electric currents had been the pile of Volta, or one of the forms of battery which had been evolved from it. Now, by Faraday's discovery, the world had become possessed of a new source. And yet again, strange as it may seem, years elapsed before the world—that is, the world of engineers—discovered that an important discovery had been made. Not till some thirty years later were any magneto-electric machines made of a sufficient size to be of practical service even in telegraphy, and none were built of a sufficient power to furnish a single electric light until about the year 1857. In the meantime in America other electric motors, to be driven by batteries, had been devised by Davenport and by Page; the latter's machine had an iron plunger to be sucked by electromagnetic attraction into a hollow coil of copper wire, thereby driving a shaft and flywheel through the intermediate action of a connecting-rod and crank. Page's was, in fact, an electric engine, with 2-foot stroke, single-acting, of between 3 and 4 horse-power. The battery occupied about 3 cubic feet and consumed, according to Page, 3 pounds of zinc per horse-power per day. This must have been an under-estimate; for if Daniell's cells were used the minimum consumption for a motor of 100 per cent efficiency is known to be about 2 pounds of zinc per horse-power per hour.

Upon the state of development of electric motors fifty years ago information may be gleaned from an exceedingly interesting debate at the Institution of Civil Engineers upon a paper read April 21, 1857, "On Electromagnetism as a Motive Power," by Mr. Robert Hunt, F.R.S. In this paper the author states that, though long-enduring thought has been brought to bear upon the subject, and large sums of money have been expended on the construction of machines, "yet there does not appear to be any nearer approach to a satisfactory result than there was thirty years ago." After explaining the elementary principles of electromagnetism, he describes the early motors of Dal Negro, Jacobi, Davenport, Davidson, Page, and others. Reviewing these and their non-success as commercial machines, he says: "Notwithstanding these numerous trials, . . . it does not appear that any satisfactory explanation has ever been given of the causes which have led to the abandonment of the idea of employing electricity as a motive power. It is mainly with the view of directing attention to these causes that the present communication has been written." He admits that electromagnets may be constructed to give any desired lifting power; but he finds that the attractive force on the iron keeper of a magnet of his own, which held 220 pounds when in contact, fell to 36 pounds when the distance apart was only one-fiftieth of an inch. To this rapid falling off of force, and to the hardening action on the iron of the repeated vibrations due to the mechanical concussion of the keeper, he attributed the small power of the apparatus. Also he remarked upon the diminution of the current which is observed to flow from the battery when the motor was running (which Jacobi had, in his memoir on the theory, traced to a counter electromotive force generated in the motor itself), and which reduced the effort exerted by the electromagnets; this diminution he regarded as impairing the efficiency of the machine. "All electromagnetic arrangements," he says, "suffer from the cause named, a reduction of the mechanical value of the prime mover, in a manner which has no resemblance to any of the effects due to heat regarded as a motive power." Proceeding to discuss the batteries he remarked that as animal power depends on food, and steam power on coal, so electric power depends on the amount of zinc consumed; in support of which proposition he cited the experiments of Joule. He gives as his own results that for every grain of zinc consumed in the battery his motor performed a duty equivalent to lifting 86 pounds 1 foot high. Joule and Scoresby, using Daniell's cells, had found the duty to be equivalent to raising 80 pounds 1 foot high, being about half the theoretical maximum duty for 1 grain of zinc. In the Cornish engine, doing its best duty, 1 grain of coal was equivalent to a duty of raising 143 pounds 1 foot high. He put the price of zinc at

* Abstracted from a paper read before the British Association for the Advancement of Science.

£35 per ton as compared with coal at less than £1 per ton, which makes the cost of power produced by an electric motor—if computed by the consumption of zinc in a battery—about sixty times as great as that of an equal power produced by a steam engine consuming coal. He concludes that "it would be far more economical to burn zinc under a boiler and to use it for generating steam power than to consume zinc in a battery for generating electromagnetical power."

In the discussion which followed, several men of distinction took part. Prof. William Thomson, of Glasgow (Lord Kelvin), wrote, referring to the results of Joule and Scoresby: "These facts were of the highest importance in estimating the applicability of electromagnetism, as a motive power, in practice; and, indeed, the researches alluded to rendered the theory of the duty of electromagnetic engines as complete as that of the duty of waterwheels was generally admitted to be. Among other conclusions which might be drawn from these experiments was this: that, until some mode of producing electricity as many times cheaper than that of an ordinary galvanic battery as coal was cheaper than zinc, electromagnetic engines could not supersede the steam engine." Mr. W. R. Grove (Lord Justice Sir William Grove) remarked that a practical application of the science appeared to be still distant. The great desideratum, in his opinion, was not so much improvement in the machine as in the prime mover, the battery, which was the source of power. At present the only available use for this power must be confined to special purposes where the danger of steam and the creation of vapor were sought to be avoided, or where economy of space was a great consideration. Prof. Tyndall agreed with the last speaker, but suggested that there might be some way of mitigating the apparent diminution of power due to the induction of opposing electromotive forces in the machine itself. Mr. C. Cowper spoke of some experiments, made by himself and Mr. E. A. Cowper, showing the advantage gained by properly laminating the iron cores used in the motor. He put the cost of electric power at £4 per horsepower per hour. He deprecated building electric motors with reciprocating movements and cranks; described the use of silver commutators; and mentioned the need of adjusting the lead given to the contacts. There was, he said, no reason to suppose that electric motors could be made as light as steam engines. Even in the case of small motors of one-tenth or one hundredth of a horse-power, for light work, where the cost of power was of small consequence, a boy or a man turning a winch would probably furnish power at a cheaper rate. Mr. Alfred Smee agreed that the cost would be enormous for heavy work. Although motive power could not at present be produced at the same expense on a large scale by the battery as by coal, still they were enabled readily to apply the power at any distance from its source; the telegraph might be regarded as an application of motive power transmitted by electricity. Mr. G. P. Bidder considered that there had been a lamentable waste of ingenuity in attempting to bring electromagnetism into use on a large scale. Mr. Joule wrote to say that it was to be regretted that in France the delusion as to the possibility of electromagnetic engines superseding steam still prevailed. He pointed out, as a result of his calorimeter experiments, that if it were possible so to make the electric engine work as to reduce the amount to a small fraction of the strength which it had when the engine was standing still, nearly the whole of the heat (energy) due to the chemical action of the battery might be evolved as work. The less the heat evolved, as heat, in the battery, the more perfect the economy of the engine. It was the lower intensity of chemical action of zinc as compared with carbon, and the relative cost of zinc and coal, which decided so completely in favor of the steam engine. Mr. Hunt, replying to the speakers in the discussion, said that his endeavor had been to show that the impossibility of employing electromagnetism as a motive power lay with the present voltaic battery. Before a steam engine could be considered, the boiler and furnace must be considered. So likewise must the battery if electric power were to become economical. Then the president, Mr. Robert Stephenson, wound up the discussion by remarking that there could be no doubt that the application of voltaic electricity, in whatever shape it might be developed, was entirely out of the question, commercially speaking. The mechanical application seemed to involve almost insuperable difficulties. The force exhibited by electromagnetism, though very great, extended through so small a space as to be practically useless. A powerful magnet might be compared to a steam engine with an enormous piston, but with exceedingly short stroke; an arrangement well known to be very undesirable.

In short, the most eminent engineers in 1857 one and all condemned the idea of electric motive power as unpractical and commercially impossible. Even Faraday, in his lecture on "Mental Education" in 1854, had set down the magneto-electric engine along with mesmerism, homœopathy, odylism, the caloric engine, the electric light, the sympathetic compass, and perpetual motion as coming in different degrees among "subjects uniting more or less of the most sure and valuable investigations of science with the most imaginary and unprofitable speculation, that are continually passing through their various phases of intellectual, experimental, or commercial development, some to be established, some to disappear, and some to recur again and again, like ill weeds that cannot be extirpated, yet can be cultivated to no result as wholesome food for the mind."

Fifty years have fled, and Hunt, Grove, Smee, Tyndall, Cowper, Joule, Bidder, and Stephenson have passed away. But the electric motor is a practical success, and the electric motor industry has become a very large one, employing thousands. Hundreds of factories have discarded their steam engines to adopt electric motor driving. All traveling cranes, nearly all tramcars, are driven by electric motors. In the navy and in much of the merchant service the donkey engines have been replaced by electric motors. Electric motors of all sizes and outputs, from one-twentieth of a horse-power to 8,000 horse-power, are in commercial use. One may well ask: What has wrought this astonishing revolution in the face of the unanimous verdict of the engineers of 1857?

The answer may be given in terms of the action and reaction of pure and applied science. Pure science furnished a discovery; industrial applications forced its development; that development demanded further abstract investigation, which in turn brought about new applications. It was beyond all question the development of the dynamo for the purposes of electrotyping and electric light which brought about the commercial advent of the electric motor. For about that very time Holmes and Siemens and Wilde and Wheatstone were at work developing Faraday's magneto-electric apparatus into an apparatus of more practical shape; and the electric lighthouse lamp was becoming a reality which Faraday lived to see before his death in 1867. That eventful year witnessed the introduction of the more powerful type of generator which excited its own magnets. And even before that date a young Italian had made a pronouncement which, though it was lost sight of for a time, was none the less of importance. Antonio Pacinotti in 1864 described a machine of his own devising, having a specially wound revolving ring-magnet placed between the poles of a stationary magnet, which, while it would serve as an admirable generator of electric currents if mechanically driven, would also serve as an excellent electric motor if supplied with electric currents from a battery. He thereupon laid down the principle of reversibility of action, a principle more or less dimly foreseen by others, but never before so clearly enunciated as by him. And so it turned out in the years from 1860 to 1880, when the commercial dynamo was being perfected by Gramme, Wilde, Siemens, Crompton and others, that the machines designed specially to be good and economical generators of currents proved themselves to be far better and more efficient motors than any of the earlier machines which had been devised specially to work as electromagnetic engines. Moreover, with the perfection of the dynamo came that cheap source of electric currents which was destined to supersede the battery. That a dynamo driven by a steam engine furnishing currents on a large scale should be a more economical source of current than a battery in which zinc was consumed, does not appear to have ever occurred to the engineers who, in 1857, discussed the feasibility of electric motive power. Indeed, had any of them thought of it, they would have condemned the suggestion as chimerical. There was a notion abroad—and it persisted into the eighties—that no electric motor could possibly have an efficiency higher than 50 per cent. This notion, based on an erroneous understanding of the theoretical investigations of Jacobi, certainly delayed the progress of events. Yet the clearest heads of the time understood the matter more truly. The true law of efficiency was succinctly stated by Lord Kelvin in 1851, and was recognized by Joule in a paper written about the same date. In 1877 Mascart pointed out how the efficiency of a given magneto-electric machine rises with the speed up to a limiting value. In 1879 Lord Kelvin and Sir William Siemens gave evidence before a parliamentary committee as to the possible high efficiency of an electric transmission of power; and in August of the same year, at the British Association meeting at Sheffield, the essential theory of the efficiency of electric motors was well and admirably put in a lecture by Prof. Ayrton. In 1882 the present author designed, in illustration of the theory, a graphic construction, which has been ever since in general use to make the principle plain. The counter-electromotive force generated by the motor when running, which Hunt and Tyndall deplored as a defect, is the very thing which enables the motor to appropriate and convert the energy of the battery. Its amount relatively to the battery's own electromotive force is the measure of the degree to which the energy which would otherwise be wasted as heat is utilized as power. Pure science stepped in, then, to confirm the possibility of a high efficiency in the electric motor *per se*. But pure science was also brought into service in another way. An old and erroneous notion, which even now is not quite dead, was abroad to the effect that the best way of arranging a battery was so to group its component cells that its internal resistance should be equal to the resistance of the rest of the circuit. If this were true, then no battery could ever have an efficiency of more than 50 per cent. It was supposed in many quarters that this misleading rule was applicable also to the dynamo. The dynamo makers discovered for themselves the fallacy of this idea, and strove to reduce the internal resistance of the armatures of their machines to a minimum. Then the genius of the lamented John Hopkinson led him to apply to the design of the magnetic structure of the dynamo abstract principles upon which a rational proportioning of the iron and copper could result. A similar investigation was independently made by Gisbert Kapp, and between these accomplished engineers the foundations of dynamo design were set upon a scientific basis. To the perfection of the design the magnetic studies of our ex-president, Prof. Ewing, contributed a notable part, since they furnished a basis for calculating out the inevitable losses of energy in armature cores by hysteresis and parasitic currents in the iron when subjected to recurring cycles of magnetization. Able constructive engineers, Brown, Mordey, Crompton, and Kapp, perfected the structural development, and the dynamo within four or five years became, within its class, a far more highly efficient machine than any steam engine. And as by the principle of reversibility every dynamo is also capable of acting as a motor, the perfection of the dynamo implied the perfection, both scientific and commercial, of the motor also. The solution in the eighties of the problem how to make a dynamo to deliver current at a constant voltage when driven at a constant speed, found its counterpart in the solution by Ayrton and Perry of the corresponding problem how to make a motor which would run at constant speed when supplied with current at a constant voltage. Both solutions depend upon the adoption of a suitable compound winding of the field magnets.

A little later alternating currents claimed the attention of engineers; and the alternating current generator, or "alternator," was developed to a high degree of perfection. To perfect a motor for alternating currents was not so simple a matter. But again pure science stepped in, in the suggestion by Galileo Ferraris of the extremely beautiful theorem of the rotatory magnetic field, due to the combination of two alternating magnetic fields equal in amplitude, identical in frequency and in quadrature in space, but differing from each other by a quarter-period in phase. To develop on this principle a commercial motor required the ingenuity of Tesla and the engineering skill of Dobrowolsky and of Brown; and so the three-phase induction motor, that triumph of applied science, came to perfection. Ever since 1891, when at the Frankfort Exhibition there was shown the *tour de force* of transmitting 100 horse-power to a distance of 100 miles with an inclusive efficiency of 73 per cent, the commercial possibility of the electric transmission of power on a large scale was assured. The modern developments of this branch of engineering and the erection of great power stations for the economic distribution of electric power generated by large steam plant or by water turbines are known to all engineers. The history of the electric motor is probably without parallel in the lessons it affords of the commercial and industrial importance of science.

But the query naturally rises: If a steam engine is still needed to drive the generator that furnishes the electric current to drive the motors, where does the economy come in? Why not use small steam engines and get rid of all intervening electric appliances? The answer, as every engineer knows, lies in the much higher efficiency of large steam engines than of small ones. A single steam engine of 1,000 horse-power will use many times less steam and coal than a thousand little steam engines of 1 horse-power each, particularly if each little steam engine required its own little boiler. The little electric motor may be designed, on the other hand, to have almost as high an efficiency as the large motor. And while the loss of energy due to condensation in long steam pipes is most serious, the loss of energy due to transmission of electric current in mains of equal length is practically negligible. This is the abundant justification of the electric distribution of power from single generating centers to numerous electric motors placed in the positions where they are wanted to work.

Gold Lacquer for Metal Articles.—A beautiful golden yellow lacquer, for metallic articles, is obtained by making a concentrated solution of picric acid in alcohol and then adding to this so much pale shellac solution, mixed with alcohol, until a sample applied with a brush shows the desired color. Then add to each 100 parts of varnish 5 parts of crystallized boracic acid, also first dissolved in alcohol. The metal lacquer is then ready for use.—Journal der Goldschmiedekunst.

HOW MATCHES ARE MADE.

THE INGENIOUS MACHINERY EMPLOYED.

BY O. BECHSTEIN.

The cheapness of matches, and the supply of a demand amounting, for the whole world, to about 2,000 million matches per day, are made possible only by the almost total elimination of hand labor from their manufacture. Almost every operation, from the sawing of the log to the filling and labeling of the boxes,

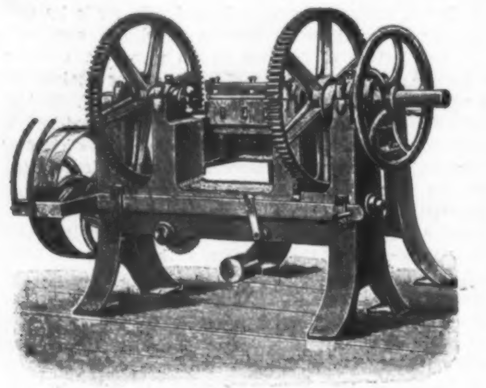


Fig. 1.—VENEER OR PEELING MACHINE.

is now performed by one or another ingenious machine.

The logs, usually of poplar, willow or linden, are first sawed into lengths of from 16 to 36 inches, and unless they are quite fresh and moist, are soaked or boiled in water in order to make the wood less brittle.

The logs are then brought to the veneer or "peeling" machine (Fig. 1). Here the log turns, as in a lathe, and a long knife set parallel to its axis shaves off a spiral ribbon or veneer as wide as the length of the log and as thick as a match. The thinner veneers of which the match boxes are made are turned off by a similar machine, or even by the same one, for the machine can be adjusted to produce veneers of any desired thickness. In making box veneers the edges of the boxes are marked by grooves which are cut by a second knife as the veneer comes off the log. Each machine furnishes material for from 10 to 17 million matches, or from 100,000 to 200,000 boxes, in 10 hours, with a consumption of from 1 to 4 horse-power.

The veneers are now laid, in piles of from 50 to 80, according to their thickness, on the bed of the splint cutting machine (Fig. 2) where they are drawn at uniform speed under a knife which falls and rises in rapid succession. This machine, although it consumes only 1 horse-power, turns out every hour about 2½ million square or rectangular splints, such as are used for nearly all safety or Swedish matches.

The round and oval splints of some sulphur matches are made on a splint planing or gouging machine, by forcing a tool having a row of holes with cutting edges against short blocks of wood, the sawdust and shavings being carried away by a blast of air. These splints are usually made of pine or spruce.

The wet splints next go to the drying oven (Fig. 3) where they are strewn loosely on shelves of wire netting and exposed to a current of hot dry air. In some factories the shelves move slowly against the current and the process is continuous, the splints

Fig. 2.—SPLINT CUTTING MACHINE.

entering wet at one end of the apparatus and coming out dry at the other end.

The rectangular splints, which at first have a rough splintery surface, are polished by mutual friction in rotating drums and then go to the cleaning machine. Here they are placed on oscillating sieves with meshes large enough to allow broken splints as well as dust and chips to fall through.

Heading is the next operation. Safety matches are dipped first in paraffin and then in the igniting mixture. Common sulphur or phosphorus matches are dipped successively in melted sulphur and in the phosphorus mixture. To make the heads uniform in size and prevent them from sticking together the splints must be held, during the dipping operations, at fixed distances apart and with their ends in one plane. These results are secured by the dipping frame (Fig. 4). This consists of a great number of thin wooden laths between which the splints are inserted and which are then pressed together by bolts or otherwise. The frame is filled with splints by the framing machine (Fig. 5) after the tangled splints have been made parallel by the straightening machine (Fig. 6). The latter has a removable bed on which is placed a chase, or bottomless box, of many compartments, each as long as a match. The bed of the machine has an oscillating motion in consequence of which the splints, as they are thrown on the chase, arrange themselves in parallel rows in the compartments as the finished matches lie in their boxes. The chase is then lifted off and the bed laden with piles of parallel splints is carried to the framing machine which inserts the splints in the dipping frame and locks the latter.

Fig. 3.—DRYING OVEN.

The filled frames are laid on a hot plate, in order to warm the splints and increase their power to absorb paraffin, and go thence to the paraffin bath (Fig. 7). This is an iron pan of the size and shape of the dipping frame containing melted paraffin which is automatically kept at a constant temperature and a constant level. The same apparatus is used for sulphur matches, melted sulphur being substituted for paraffin. The edge of the frame is laid on the edge of the bath and as the splints project equally from the frame all are immersed to the same depth. With this apparatus 5,000 or 6,000 frames, containing 10 or 12 million splints, can be dipped in a day.

The frame containing the paraffined splints now goes to the heading machine (Fig. 8) where it is pressed down, by a plate or a roller, upon a layer of the igniting composition which is spread to uniform thickness on an iron plate. The first dipping is followed by a series of immersions to a less depth in order to increase the size and perfect the form of the heads. A machine provided with a roller can head from 11 to 17 million matches per day.

The matches are finished when they leave the heading machine. The frames are emptied with the aid of an apparatus which resembles the framing machine in construction and use, except that the matches stand on their heads in the compartments, into which they fall when the frame is unlocked. The bed of the machine and the chase which rests upon it oscillate as frame after frame is emptied, in order to pack the matches tightly in the compartments. Then the sliding bed is withdrawn and the matches drop into a drawer in which, still standing on their heads they are tightly packed by the return of the sliding bed above them. In this drawer they are carried to the boxing machine (Fig. 10).

The wooden boxes in which the matches are packed are made from thin veneers by the box-making machine (Fig. 9) which is fed automatically and continuously with veneers, paper, and paste. By a very complicated mechanism which cannot here be described in detail, the veneer is bent over a form and

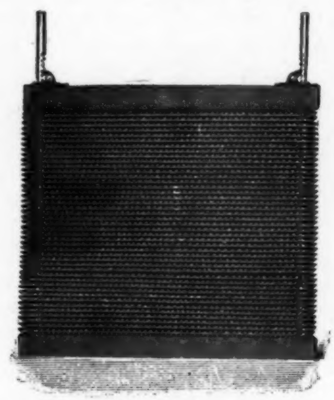


Fig. 4.—DIPPING FRAME.

fastened with strips of paper which the machine cuts, spreads with paste, applies to the edges of the nascent match-box, and presses with rollers. Two distinct machines, differing in detail, but constructed and operating on the same general principles, are required, one for the inner box or drawer, the other for the outer box or holder. Both parts go through drying apparatus and thence to a machine which, by an ingenious application of endless aprons, puts them together and applies the labels.

The closed boxes are taken, in carriers holding from 200 to 300, to the box reservoir shown at the right end of the boxing machine (Fig. 10) which delivers them, singly and successively, to a moving chain of little iron plates by which they are carried to the match reservoir at the other end of the machine. On their journey they pass a device which pushes them open but leaves one end of the drawer fast in the holder. The matches glide down from the large drawer in which they have been brought to the machine to the filling apparatus below, which divides the stream into boxfuls and drops these into the open boxes as they pass. Still carried by the endless chain, the filled boxes next pass a mechanism which closes them and finally return to the box reservoir, where they are pushed off into a receptacle, a filled box leaving the

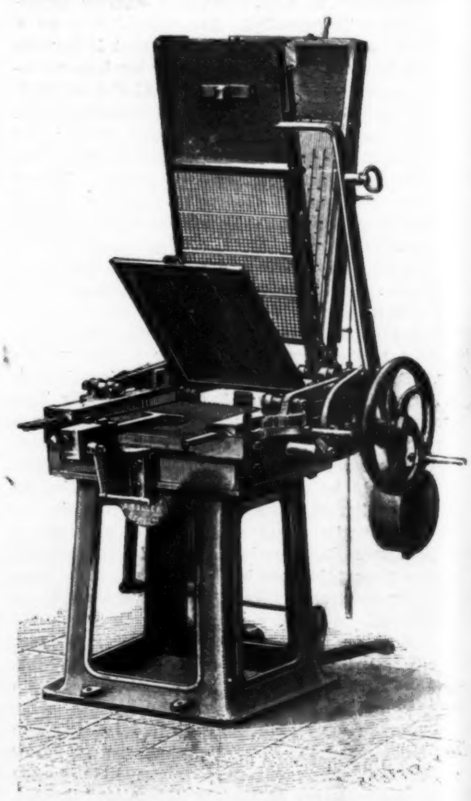


Fig. 5.—FRAMING MACHINE.

endless chain as each empty box is placed upon it. The filled boxes then go to the coating machine, which applies the coatings of red phosphorus to the sides of the outer box. The boxes, standing on end, are carried by an endless band between two revolving brushes, to which the composition is conveyed from a reservoir by two revolving disks. Then the boxes are carried by the endless band between hot pipes, in order to dry the composition.

They go next to the packing machine (Fig. 11)

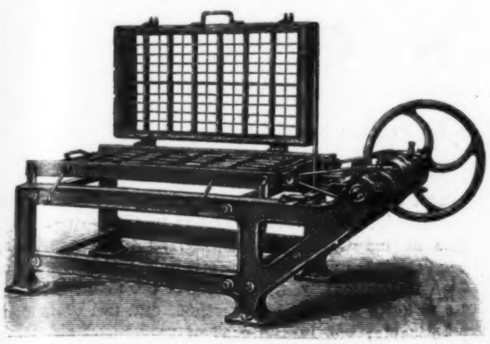


FIG. 6.—STRAIGHTENING MACHINE.

which assembles them in tens or dozens, wraps each package in paper which it automatically cuts from a roll, folds and pastes, and finally affixes a label. This machine is of 1 or 1.5 horse-power and turns out from 12,000 to 15,000 packages in a day.

Usually the first human hand to touch a match is the hand of the consumer, for all the machines described above are automatic, and manual labor is employed only in conveying the splints and matches—in carriers—from one machine to another. These machines perform their delicate tasks not only more rapidly but also more perfectly than could be accomplished on such a scale by skilled hand workers.

FIG. 7.—PARAFFIN BATH.

Hand work is eliminated still more completely by the "Automaton" match machine illustrated by Fig. 12, which performs, automatically and continuously, the successive operations of framing, paraffining, heading, drying and boxing without the intervention of human hands, which are employed only in bringing splints, paraffin, heading composition and empty boxes to the machine, and taking filled boxes away. This machine, like the others herewith illustrated, is made by A. Roller, Berlin. Its operation is as follows:

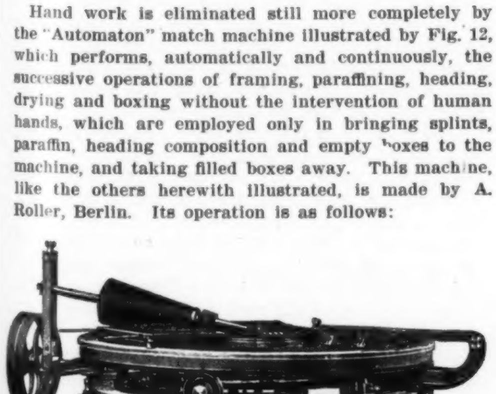


FIG. 8.—HEADING MACHINE.

The splints, assembled in chases or tied in bundles about 16 inches in diameter, are put into an oscillating hopper and shaken down into the grooves of its corrugated bottom. Hence they are pushed, singly, by a row of plungers, into the corrugations of a second plate called a bridge, which moves forward when each groove has received a splint. In front of the bridge hangs a wide chain of steel plates, perforated with holes of the diameter of a splint and 1/3 inch distant from each other. As the bridge moves forward a follower rises behind it and forces the forward ends

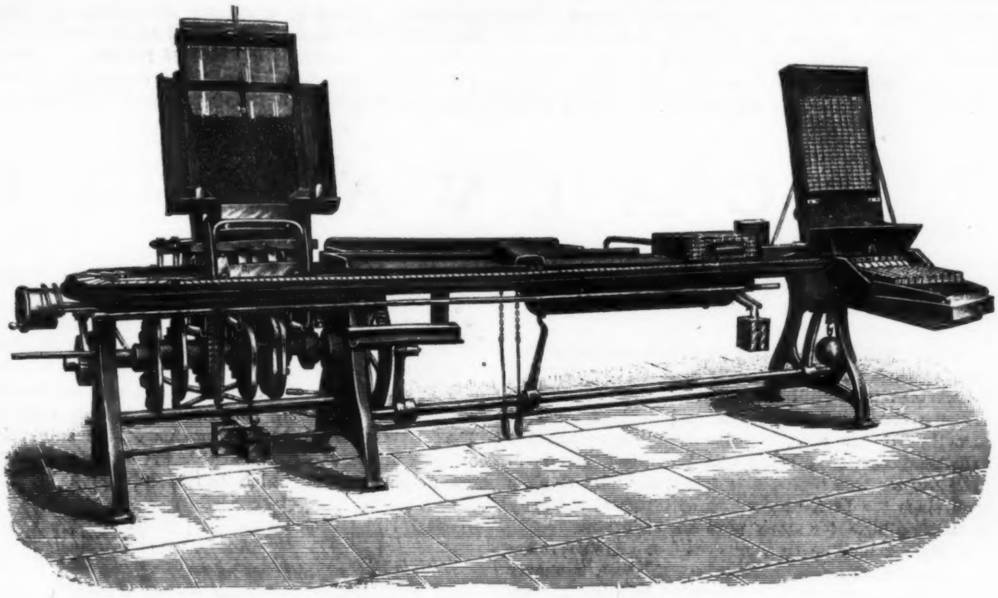


FIG. 10.—BOXING MACHINE.

of the splints into the holes of the chain plates. The follower then sinks, the bridge returns to its first position, the chain moves downward far enough to bring the next row of holes opposite the grooves of the bridge, and the series of operations is repeated indefinitely. Hence the portion of the endless and intermittently advancing conveyor chain which hangs below the bridge bristles with splints, like the dipping frames already described. As the chain moves onward the splints are carried over a steam-heated table to the paraffin bath, into which they dip lightly, and thence to the heading apparatus. This consists of a trough, in which the heading composition is continually agitated by a stirrer, and a grooved cylinder

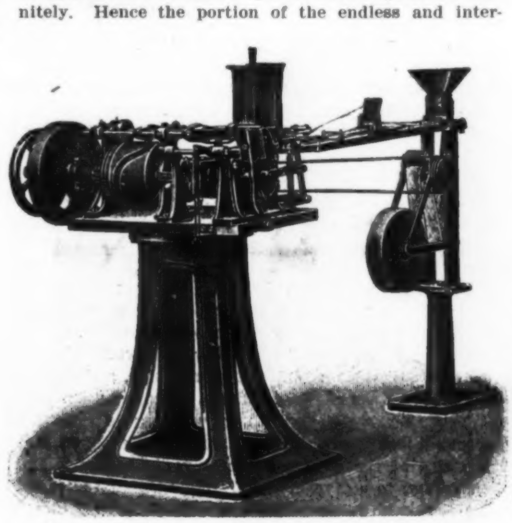


FIG. 9.—BOX MAKING MACHINE.

partly immersed in the mass. As the cylinder turns the grooves become filled with composition and apply it to the ends of the successive rows of splints. The size of the heads can be regulated by slightly raising and lowering the cylinder.

The matches proceed, with their heads down, to the end of the apparatus, where the chain passes around a perforated drum about 4 feet in diameter in such a manner that the heads of the matches are directed toward the axis and are exposed to a blast of cold air. After leaving the drum the chain passes

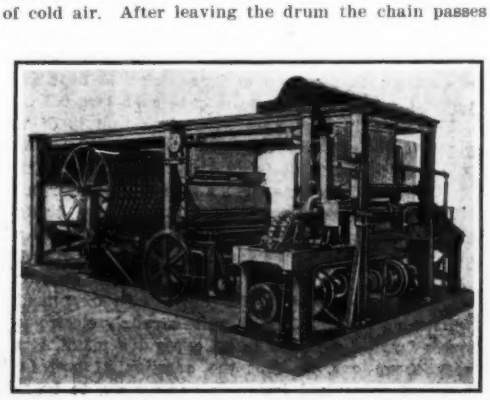


FIG. 12.—"AUTOMATON" MATCH MACHINE.

around two rollers and then horizontally under the roof of the machine, exposing the heads of the matches, which are now directed upward, to a blast of hot air furnished by a second blower, which completes the drying.

At the other end of the apparatus the chain passes under a rod set with short teeth which expel the matches from the holes of the chain plates. The matches fall on a plate which has little trough-like depressions and moves alternately up and down in such a manner that each trough receives five matches and drops them into a match box, in each cycle. The boxes,

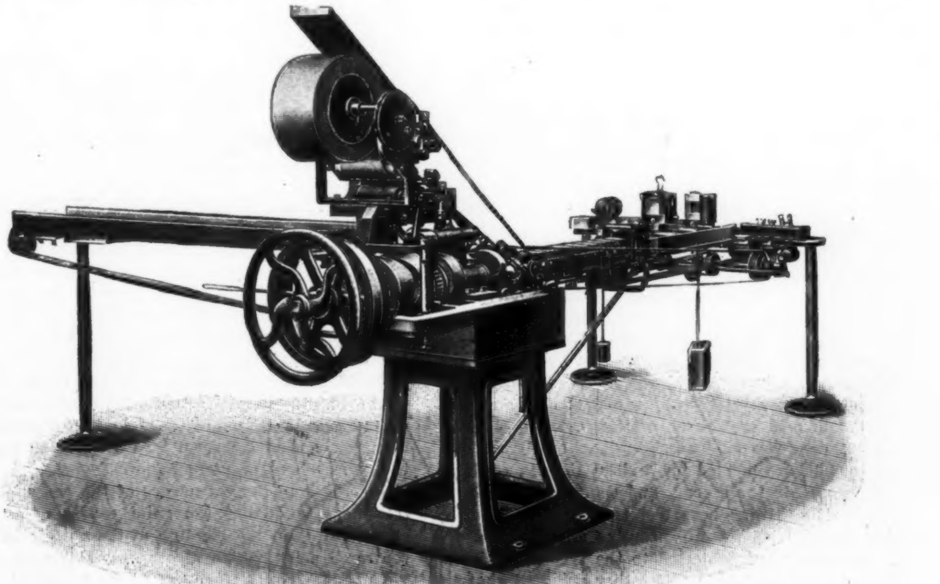


FIG. 11.—PACKING MACHINE.

opened but not separated, have been placed in two hoppers which deliver them to a broad conveyor chain, at the same time completely separating the inner and outer boxes and arranging them in parallel rows on opposite sides of the chain. The chain moves intermittently, each advance being equal to twice the interval between successive boxes, and at each halt 26 boxes are under the 26 troughs of the filling plate, each of which deposits 5 matches in the box beneath it. Hence each box receives 65 matches. The inner boxes, as they lie on the conveyor chain, are surrounded with guards which prevent the matches from falling outside and the regular arrangement of the matches is insured by a shaking and jarring mechanism. Next the boxes are closed and dropped into a basket.

The entire apparatus is about 26 feet long, 15 feet wide, and 8 feet high. Hence it occupies much less room than the separate framing, warming, paraffining, heading, drying and boxing machines which it replaces. It consumes only 2.5 horse-power and produces daily about 50,000 boxes, containing 3¼ million matches—nearly enough to supply a city of 300,000 inhabitants. It is so accurate that the greatest variation found in the number of matches in a box does not exceed 3 per cent, with any of the 30 machines now in operation.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

GALVANIZING.—I.

SOME PRACTICAL SUGGESTIONS.

ZINC is a metal which quite easily oxidizes under the influence of air and water, but to so slight an extent that it is well adapted for such purposes as covering roofs, and also for making various kinds of utensils. It has been discovered that zinc has the valuable property of being able to protect iron from rust, and for this reason it is frequently used to plate iron, since the iron, on account of its great strength, is more suitable for many purposes than zinc.

A coating of zinc on iron does not merely protect it, as in the case of tinning, where the iron is simply covered, so that a sheet of tin-plated iron has the appearance of a sheet of tin. Zinc is a very strongly electro-positive metal; brought in contact with iron, a galvanic element is generated, and the iron, on account of the constant development of electricity, acquires greater power of resistance to rust. In consequence of this special action, zinc-plated iron is called galvanized iron, and it is not necessary to the preservation of the iron that the entire surface of the iron should be covered with zinc. According to experiments which have been made on this subject, places as large as 12 square millimeters, on galvanized iron exposed to the air, may be free from zinc, without disadvantage; in the case of iron which is kept under water, the uncovered spots may be even larger.

This fact in regard to galvanized iron is of very great value for many technical purposes; and galvanized iron is undoubtedly superior in point of durability to tinned iron, since in the case of the latter oxidation sets in very strongly on any places, however small, which are not covered with tin, and holes will soon be made in the plate at these spots. Iron, in contact with tin, becomes electro-positive, and acquires a much stronger tendency to unite with oxygen than when alone; by itself it is quite strongly electro-negative. Besides this, tin is an expensive metal, zinc a very cheap one, so that the question of cost is in favor of galvanized iron. In appearance, to be sure, it is inferior to tin-plated iron, since it shows the dull gray color of zinc, while the tinned iron has the fine white color and the high luster of tin. In cases where the durability is of more consequence than appearance, the galvanized metal has the advantage over the tinned.

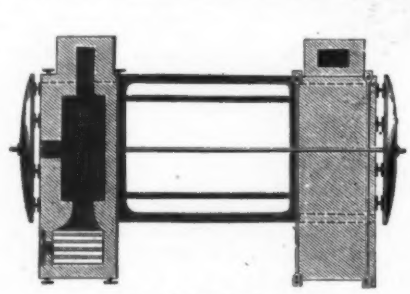
Galvanizing of Iron.—Galvanizing is an operation which was fairly well known for a long time before it was performed on a large scale. As early as 1742 it was stated by Malonin that a kind of white sheet metal was to be obtained by treatment of iron with zinc; and there exists a description by Watson, dating from the year 1786, of the galvanizing process, which, in all the principal points, was identical with the method employed to-day.

Only in more recent years, however, since about 1840, has galvanizing been done on a large scale. At present, iron used for building purposes is much more frequently subjected to galvanizing than to the more expensive and less desirable process of tinning. Galvanizing is especially valuable for iron utensils to be used in stables, and for telegraph wires. In the latter case it has been observed that wires properly galvanized will be scarcely at all affected by a year's exposure, while plain iron wire would be entirely rusted long before the expiration of this time.

The work of galvanizing sheet iron is begun by pickling the metal. This can be done with sulphuric acid or hydrochloric acid, but the latter is now used almost exclusively, as it is much cheaper than sulphuric acid, and does equally good service.

According to the method employed in England, three vessels are used in the pickling process, the first and third containing a mixture of one part by volume of hydrochloric acid and seven of water, while the second holds pure water. The sheet iron, or the articles made from it, are pickled for a short time in the first trough, rinsed in the second, and the metallizing completed in the third, whereupon they are placed in a drying chamber, at a temperature of about 50 deg. C., and left there until subjected to the real galvanizing.

Instead of hydrochloric acid, other and still cheaper fluids can be advantageously used, as, for example, the acid liquids left from refining oil. Oil is refined by stirring it together with a certain percentage of sulphuric acid, which carbonizes the vegetables substances floating in the crude oil, and then separates again beneath the oil, colored dark by the carbon. The oil is freed from the remains of the sulphuric acid, by means of water, and this water, together with the sulphuric acid which has been colored by the



CLAY MELTING PAN.

carbon, is a cheap and very suitable agent for pickling sheet iron intended to be galvanized.

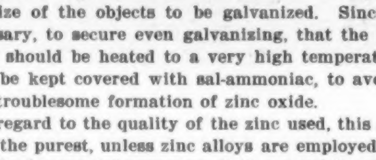
Still other pickling fluids are recommended, such as a fluid consisting of 2 parts of tin-salt, 2 parts of blue vitriol, 5 parts of sulphuric acid, and 45 parts of water. The pickled sheets are scoured, in places where this is necessary, with fine, sharp sand, to make them perfectly smooth and bright, and kept under water until the time for galvanizing.

After being made bright by either method, and before being put into the zinc bath, they are dipped either in a solution of sal-ammoniac in water, or in a mixture of 30 parts of water, 30 of hydrochloric acid, 2 of zinc chloride, and 1 of sal-ammoniac, and dried so quickly that a whitish salt-film is deposited upon them.

The zinc to be used in galvanizing is melted in wrought-iron pans, whose dimensions correspond to the size of the objects to be galvanized. Since it is necessary, to secure even galvanizing, that the melted metal should be heated to a very high temperature, it must be kept covered with sal-ammoniac, to avoid the very troublesome formation of zinc oxide.

In regard to the quality of the zinc used, this should be of the purest, unless zinc alloys are employed intentionally for special purposes; if the metal has become impure by long use, it should be removed from the galvanizing pans, instead of adding more pure zinc.

The heating of the melting pans requires considera-



GALVANIZING MELTING APPARATUS.

ble experience on the part of the workmen, as they must know the exact point at which the zinc is hot enough and fluid enough to effect the galvanizing quickly; for if the sheet iron is immersed for too long a time in the molten zinc, quite a thick layer of zinc and iron alloy will be formed which is so brittle that it would be hardly possible to roll or stamp the plate.

The objects to be galvanized are dipped into the melted zinc by means of tongs, left a few seconds, and then removed and thrown into a vessel of water near the pans, where they are left until cool.

According to the experience of the writer, this very treatment is one of the chief causes of brittleness, even more than the pickling of the objects in too concentrated acids, which also causes this very undesirable phenomenon. If it can be so arranged that the water into which the galvanized metal is thrown is boiling hot, and cools slowly, this brittleness can be almost entirely avoided, in case the zinc has not been overheated; a still better way is to throw the objects into melted tallow or palm-oil, as these oils, being poor conductors of heat, permit only a very slow cooling. Unfortunately, the cooling of the metal in melted fat is quite an expensive method, and not everywhere practicable; but in the case of galvanized sheet iron from which ornaments, etc., are to be made by stamping, this manner of cooling is most earnestly to be recommended, as the sheets will come out perfectly pliable.

The objects which have been cooled in water are ready for use after being dried and brushed with bran or saw-dust; if fat has been used, the metal, while warm (50 to 60 deg. C.), is left to drip, washed in weak lye, rinsed in water, and finally rubbed dry with soft cloths.

To produce galvanized sheets which have a still greater power of resistance to atmospheric influences than those covered with pure zinc, and which are also more ductile, zinc and lead alloys are used and also alloys of lead, tin and zinc. An alloy which gives sheets of great durability and very pliable, consists of 100 parts of zinc, 30 of lead and 70 of tin.

The handling of large sheets of metal in the zinc bath is attended with difficulties, and therefore pans have been constructed with rollers which lie under the surface of the zinc, and on which the sheets of iron are pushed along. In other similar arrangements, there are two rollers which take hold of the sheet and slowly push it through the pan; at the other end it simply has to be taken with tongs and lifted out.

Iron is a metal which quite easily forms an alloy with zinc, and for this reason, if ordinary iron pans are used for melting the zinc, they will in a short time become full of holes, and will have to be replaced, at considerable expense. The pans can be made more durable by applying to them, when new, a fluid consisting of water into which a small quantity of sodium silicate has been dissolved, and clay stirred in until the fluid looks milky. This is put on with a brush, and the first coat allowed to dry before the second is applied. This is to be repeated until the surface of the iron is no longer visible, and the whole inside of the pan covered with a uniform coating. The pan is now left standing for some days, then a small fire is made under it and it is heated slowly to a temperature of about 100 deg. C., when the coating will have become perfectly dry and firm. Then a little zinc is first put into the pan and brought to melting, and afterward it is filled as desired.

If care is taken that the objects put into the zinc bath do not strike the bottom of the pan, and if this is always heated slowly, a pan lined as above described will last for several years before becoming worn to holes.

Instead of the iron melting pans, an apparatus can be used which contains a clay melting pan, and this is very durable. As shown in the illustrations, the apparatus consists of the melting vessel, whose bottom is of stamped fire-clay. The fire heats the portions of the zinc along the sides, and since the metal is so good a conductor of heat, this is sufficient to melt the whole of it.

The flames from the fire are forced into contact with the metal by the heating pipes. The zinc is put in at the doors, and at these also the impurities floating on the zinc are removed with rakes; the fire gases pass off through the chimneys.

To protect the melted zinc as much as possible, the clay vessel is covered with iron plates, which can be raised or lowered by mechanical contrivances. Over the melting pan a heavy iron rod runs horizontally, on which are a chain and pulley by means of which heavy objects can be lowered into the bath and lifted out again.—Translated from Friedrich Hartmann's book "Das Verzinnen, Verzinken, etc., der Metalle."

Tailor's Chalk.—Ordinary pipe clay is softened with water and worked up with ultramarine, yellow or red ocher, according as blue, yellow, or red is required. Slices are cut from the mass and pressed in oiled wood or metal molds. Dry slowly in the air.

LORD RAYLEIGH.

THE MOST VERSATILE OF ENGLISH SCIENTISTS.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

"THE most exact experimenter of his time," is the opinion expressed by Sir Oliver Lodge, of Lord Rayleigh, an eminent scientist's tribute to a brother physicist. In these words are summed up the characteristics of the celebrated co-discoverer of argon. Accuracy and precision of thought and statement are his most characteristic traits. Although possibly Lord Rayleigh has not startled the world quite as much as several of his *confrères*, yet he has achieved a success that is given to but few laboratory investigators.

Lord Rayleigh is a man of great mathematical attainments, extraordinary experimental skill, and versatility. His learning covers the whole gamut of science and physics, while his investigations have been carried out in nearly all their ramifications, comprising theory of gases, flow of liquids, capillarity and viscosity, chemical physics, photography, optics, color, vision, electricity and magnetism, mathematics, wave theory, sound, and hydrodynamics—truly an extensive range for one man.

Before he succeeded to his father's title, Lord Rayleigh was known as the Hon. J. W. Strutt. He was born November 12, 1842, so that he is now in his sixty-sixth year. He received his primary education at a small school in Torquay, and early displayed a great aptitude for mathematics, that branch of science in which he was predestined to become so prominent. In 1861, he entered Trinity College, Cambridge University. Four years later he obtained the blue ribbon of the university by graduating in the mathematical tripos as senior wrangler, and was awarded the first Smith's prize. The eminent physicist enjoys the distinction of being the only English peer who has been senior wrangler. The following year he was made a fellow of the university.

In the years 1871 and 1872 Lord Rayleigh came prominently forward in the scientific world by his experiments and papers concerning optics. The color of the atmosphere was one of the most interesting topics upon which he shed much new light. He showed that the blue color of the sky is attributable to the scattering of light of the shorter wave lengths by the finer particles sustained in the air, and that the color of this light and its polarization are accounted for by the undulatory theory. He successfully supported Fresnel's theory concerning the nature of the vibrations and their relation to the plane of polarization.

Indeed, Rayleigh's investigations in the science of optics cover a wide range, and his results have cleared up satisfactorily and conclusively a number of points which have hitherto been subjects of diverse contentions. His researches concerning the reflection of light from transparent surfaces and the determination of how much is reflected and how much is transmitted were highly interesting. It is no easy matter to discover the degree of reflection in any given instance, though Fresnel had solved the problem some time previously. Subsequent experimenters, however, had arrived at many difficult conclusions, and the consequence was that theory and experiment were by no means in harmony. It was at this stage that Rayleigh devoted himself to the study of the subject, and successfully reconciled experiment with theory. For the purposes of his experiments he prepared a multitude of ingenious devices. His tests were carried out upon the surface of clear water. It was imperative that the surface of this water should be free from the slightest trace of impurity, otherwise his minute calculations would be disturbed. One of his ingenious contrivances was an expanding hoop of steel which in a concentrated state was brought into contact with the surface of the cleaned water. It then expanded and carried away or thinned down to a very minute point any impurity that might still exist. The upshot of these experiments substantiated Fresnel's theories.

Rayleigh also considerably extended our knowledge concerning optical instruments by his researches on the subject of apertures. He proved conclusively that the large aperture was essentially for giving clear and sharp definition, and he conclusively demonstrated that under certain conditions little advantage accrued from the use of a lens, and that a telescope could be made simply of the aperture and eye alone. Curiously enough it was by these experiments that Rayleigh did much to popularize pin-hole photography. His researches into this abtruse problem were remarkably thorough, and photography greatly benefited from his results, because his experiments threw much valuable light upon the question of shutting or stopping down the lens.

In 1873 Rayleigh was elected a fellow of the Royal Society. Two years previously he had contributed a paper on resonance which excited widespread attention.

In the years 1877-1878 Rayleigh published his work on the theory of sound which is considered one of the great works on the subject. It was this volume that the celebrated Professor Helmholtz declared "merited in the highest degree the thanks of all who study physics and mathematics."

In 1879 Clerk Maxwell's office at Cambridge was vacant and Lord Rayleigh was appointed successor. The Cavendish laboratory had only just been founded and at once Rayleigh set to work to complete the organization of the institution. It was under his supervision that a system of practical instruction in experimental physics was inaugurated. It was also during his five years at this college that the various electrical standards were first accurately determined by him.

Scientific men had never been able to explain how it is that a soap bubble can exist. Rayleigh supplied the missing explanation. It is a curious fact shown by

Rayleigh

Rayleigh and others, but it is only with a very few liquids that soap bubbles can be blown. The reason is that some cannot lather even if shaken up vigorously, while others lather with complete ease. The natural question, therefore, arose, "Why is it that some liquids lather and others will not, and how is it that a sphere of liquid film of almost infinitesimal thickness can exist in a still moist atmosphere for hours and even days? This was all exhaustively explained for the first time by Rayleigh.

The explanation is partly a question of physics and chemistry and it may be succinctly described according to Sir Oliver Lodge as follows: "A surface which possesses the minutest trace of scum has less tension than a clear or lesser scummed surface, and such a scum, no matter how thin it may be, has the tendency to slide down if its liquid support or foundation displays any inclination to the horizon. Furthermore a lathering liquid has a complex and resistible constitution sufficient to yield by partial dissociation, owing to the tension of the surface, a quasi-solid scum, while the constant tendency of the viscous liquid to slip between two layers of scum is a very slow process."

But it is by the discovery of a third constituent in the atmosphere that this physicist is most widely known. In the early eighties he devoted his attention to atmospheric phenomena. In the course of these researches and calculi he became convinced that the air was not composed solely of the gases popularly believed. He observed that chemically prepared nitrogen was slightly dissimilar in weight from atmospheric nitrogen, and it was this slight discrepancy that set him thinking and experimenting.

It was while he was embarked upon this momentous quest that Sir William Ramsay, the eminent chemist, sought permission to co-operate in the same work. With his characteristic good nature and appreciation of the fact that they were both working for a common cause Rayleigh at once acceded to the suggestion. But although prosecuting the same subject each worked independently after his individual method, communicating progress and the results of their investigations at frequent intervals to each other.

This was an interesting research. The physicist adopted absolutely different processes from those of the chemist. Ramsay isolated the gas by the furnace process commonly utilized by chemists. Rayleigh, on the other hand, separated the gas by acting upon an electrical method of Cavendish for the consumption of the other constituents with the oxygen. The two achieved their object by these different methods and the announcement was communicated to the world conjointly.

The discovery of this new and third element in the atmosphere was a portentous achievement, for the atmosphere was proved to be more complex than it had hitherto been considered. Rayleigh, from the results of this experiment hinted at first that argon was not the only new element existent in the air. Soon afterward still a fourth constituent was found in xenon.

No matter what realm of science one may refer to, one is almost certain to find some trace of Rayleigh's investigations in a greater or lesser degree. This versatility alone is a sufficient monument to his work.

One very prominent feature of Lord Rayleigh's work is the ingenuity he exercises in rendering even the most abstruse problems perfectly lucid by experiments and demonstrations.

When he succeeded to his father's title Lord Rayleigh by no means relinquished his scientific studies. He is the third holder of the title. He is a most indefatigable worker and spends the greater part of his time in his extensive and splendidly equipped laboratory at the family seat in Essex. It is in the quiet seclusion of this pretty sylvan retreat that he prosecutes his experiments and deductions. His work is the sole aim of his life. Apart from his scientific pursuits he has but one great hobby—dairy farming. His dairy farm is a perfect model. From a small beginning, it has grown until now he has a herd of over 1,000 cows. In dairy farming the physicist has proved equally successful, and the milk which is noted for its high standard of excellence is regularly dispatched to the London market every morning.

Between scientific investigations and farming Lord Rayleigh finds time to compile eminent books and to write highly valuable papers upon the many branches of science in which he has gained such high distinction. His works upon sound, heat, and other branches of physics are standard books upon their respective subjects.

Placuna placenta, the oyster from which pearls are said to be obtained in Ceylon, is found abundantly along the west coast of India as far north as Sind, and is collected for the sake of the pearls which it commonly contains. It differs greatly from the true pearl oyster not only in appearance, but in habit. A full-grown *Placuna placenta* is a pair of roughly circular plates, measuring about 6 inches in diameter. They are thin and white, the inner surface of each being pearly, and the outer rough and laminated, but often suffused with a lovely pink iridescence. The upper shell is slightly concave on the inside, and the lower slightly convex, so that, when they are fitted together, it appears as if no space at all were left between them. There is enough, however, for the accommodation of the thin, flat mollusk. They are found lying unattached on muddy bottoms, in creeks and estuaries, at a depth of a few feet, and occur in enormous numbers in certain areas during certain years. It seems probable that they have some power of motion, like the scallop shell (*Pecten*). About five per cent of the mature shells are said to contain pearls, which lie loose between the mollusk and the shell. They are small and often misshapen, so that only the best of them are fit for the purposes of the jeweler; but they are worth nearly $10 per ounce all round, having a high place in the mysteries of Indian medicine, and also yielding, when calcined, the finest quality of the black powder with which Indian beauties enhance the luster of their eyelids. At Kurrachee, in Sind, these pearls are a government monopoly, inherited from the Mirs, and the right to collect them is farmed out. The amount realized has varied from less than $500 to more than $3,000 a year. The work of collection is attended with none of the dangers and

difficulties of diving for true pearls. When the tide is well out, naked fishermen paddle about the creek in their canoes, and dropping into the water in likely places, where it is not more than breast de... feel for shells with their toes, with which they also bring them up, for these people have prehensile feet, like apes. When the canoes are full they are paddled to a bank where the farmer's men sit opening the shells one after another, and feeling with their thumbs among the soft vitals of the mollusks. The shells are thrown aside, and form extensive odoriferous banks.—Knowledge and Scientific News.

A RECONSTRUCTION OF IMPERIAL ROME.

HOW ROME APPEARED IN HER DAYS OF MAJESTY.

VERY few of the tourists who gaze at the melancholy ruins of ancient Roman monuments and buildings possess the historical knowledge and the vivid imagination required to evolve a comprehensive mental picture of the beauty and majesty of the imperial city. Nor do the most elaborately drawn plans and panoramas give a satisfactory and realistic impression. What is needed is a reconstruction in three dimensions on a sufficiently large scale.

A Roman sculptor, Prof. Marcelliani, has made such a reconstruction with the assistance of a number of eminent antiquarians. Marcelliani's plastic panorama, which was recently put on exhibition opposite the entrance to the Forum Romanum, is remarkable for scientific accuracy and minuteness of detail as well as for artistic effectiveness. A good idea of the work, which is about fifty feet long and twenty-six feet wide, may be obtained from the photographs herewith reproduced.

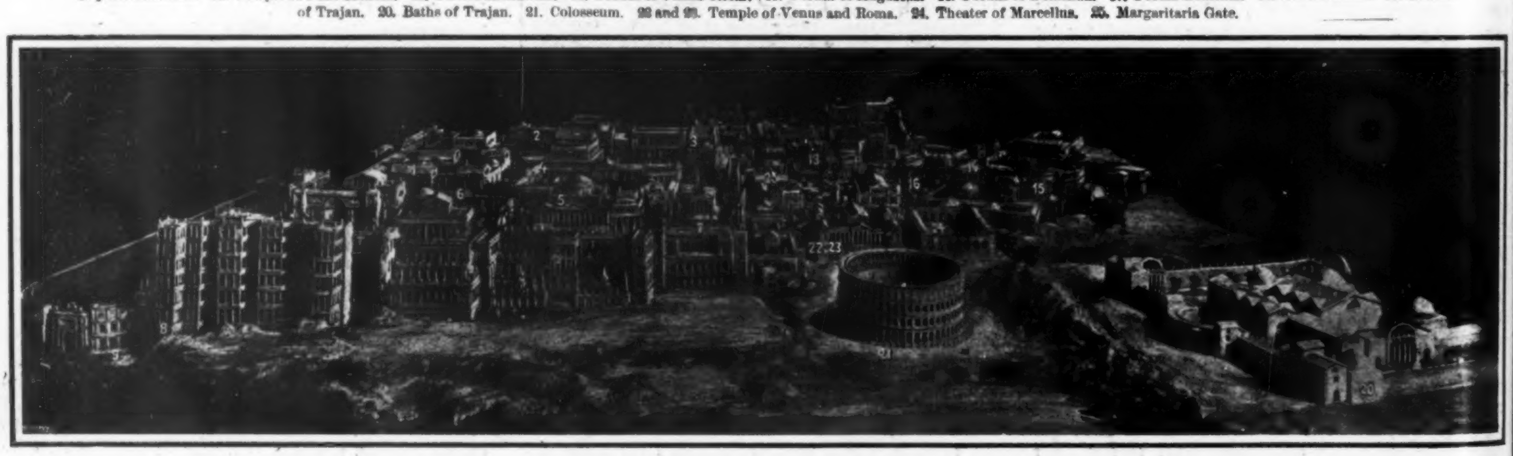
The oldest part of Rome was the settlement on the Palatine hill founded, according to tradition, by Romulus. From this small beginning developed the republican City of the Seven Hills and the imperial capital which in the reign of Aurelian covered an area of nearly fifty square miles. On the Palatine stood the palaces of Augustus (marked 1 in the photographs), Tiberius (2), Caligula (3) and their successors, for the Palatine always continued to be the imperial residence. Near the palace of Augustus stood the Temple of Apollo (4), erected by the same emperor. It was adorned with statues of the fifty daughters of Danaos and the fifty sons of Aegyptos, who wooed and won the Danaides by force and were, with one exception, slain by their reluctant brides. The Library of Apollo (5) was stored with the master works of Latin and Greek literature. The Stadium (6) erected by Domitian was used for races, prize fights, animal baiting and other popular sports. The Temple of Adonis (7) was adorned during the Adonis festivals with perishable hothouse flowers, as symbols of the transitory character of beauty. A large part of the imperial residence having been destroyed by fire in the reign of Commodus, it was rebuilt on a more magnificent scale by Septimius Severus who added, among other things, the Septizonium (8), a large rectangular structure composed of seven stories arranged like terraces on the slope of the Palatine hill and surrounded by colonnades. The vast Circus Maximus (9) which accommodated 385,000 persons, was also on the Palatine.

On the Capitoline hill stood the capitol or citadel (10), the stronghold whose possession determined that of the city. The walls of the capitol sheltered the temple of Juno Moneta (12) and the gilded Temple of Jupiter Maximus (11). At the foot of the capitol, between the Palatine and Esquiline hills, extended the Forum Romanum (13) with its numerous temples, basilicas and triumphal arches. Here was the focus of civic life and here were held the principal courts, markets and public meetings. There were, however, several other forums, which served similar purposes. Most of them were open spaces, surrounding temples and girt by roofed colonnades. Such were the Forum of Julius Cæsar (14) in the northern part of the city, the Forum of Augustus containing the Temple of Mars Ultor, or Mars the Avenger (15), the Forum of Domitian (16), the Forum Boarium (17), and the Forum Pacis (18) which is said to have been traversed by a stream of molten gold when its temple, dedicated to Pax, the god of Peace, and containing the treasures taken from Solomon's Temple in Jerusalem, was destroyed by fire. Largest and most magnificent of all was the Forum of Trajan (19), in which stood the Basilica Ulpia, the gilded temple dedicated to Trajan and his consort Plotina, and the stately column that rose above the golden urn in which Trajan's ashes were buried.

The Baths of Trajan (20) were not only a luxuriously appointed bathing establishment, supplied by natural springs, but included gymnasiums and halls for social intercourse and were adorned with the works of eminent artists. Here were found the great marble basin and the famous Laocoon group which are now preserved in the Vatican. Among the remaining structures which are reproduced in Prof. Marcelliani's remarkable work the most noteworthy are the Colosseum or Flavian Amphitheater (21), the temples of Venus and Roma (22 and 23) erected by Hadrian, the Theater of Marcellus (24), and the Margaritaria Gate (25), before which the goldsmiths and jewelers plied their trade.—Umschau.

AS VIEWED FROM THE EAST.

1. Palace of Augustus. 2. Palace of Tiberius. 3. Palace of Caligula. 4. Temple of Apollo. 5. Library of Apollo. 6. Stadium. 7. Temple of Adonis. 8. Septizonium. 9. Circus Maximus. 10. Capitol. 11. Temple of Jupiter Maximus. 12. Temple of Juno Moneta. 13. Forum Romanum. 14. Forum of Julius Cæsar. 15. Forum of Augustus. 16. Forum of Domitian. 17. Forum Boarium. 18. Forum Pacis. 19. Forum of Trajan. 20. Baths of Trajan. 21. Colosseum. 22 and 23. Temple of Venus and Roma. 24. Theater of Marcellus. 25. Margaritaria Gate.



AS VIEWED FROM THE WEST.

PROF. MARCELLIANI'S PLASTIC PANORAMA OF IMPERIAL ROME.

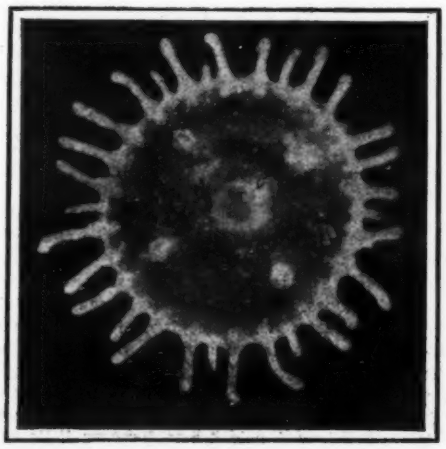
Serum treatment, which has been so successful in diphtheria, has lately been extended to scarlet fever. The serum is obtained from horses inoculated with streptococci from the blood of scarlet fever patients. Dr. Pulawski has published a discussion of 117 cases of scarlet fever, occurring between 1904 and 1907. Of the 48 patients who were treated by the usual methods 20 died, but of the 69 who received the serum treatment only 10 died. In other words, the mortality was 41.6 per cent with the old methods and only 14.5 per cent with the serum treatment. In 28 very grave cases treated without serum the mortality was 71 per cent, while it was only 28 per cent in 35 equally severe cases in which the serum treatment was employed. The 10 cases in which death resulted despite the serum treatment had appeared hopeless from the beginning. In all the other serious cases the serum not only exerted a marked remedial action, but it entirely prevented the after effects—inflammation of the ears, swelling of the glands, kidney disease, etc.—which so often follow scarlet fever. In a case of scarlet fever complicated with diphtheria, a combination of the two serums proved very successful. In lighter cases the duration of the disease was much shortened by the use of the serum. The only unpleasant effect was an eruption similar to that caused by diphtheria serum, but this was of short duration.

ZOOPHYTES.

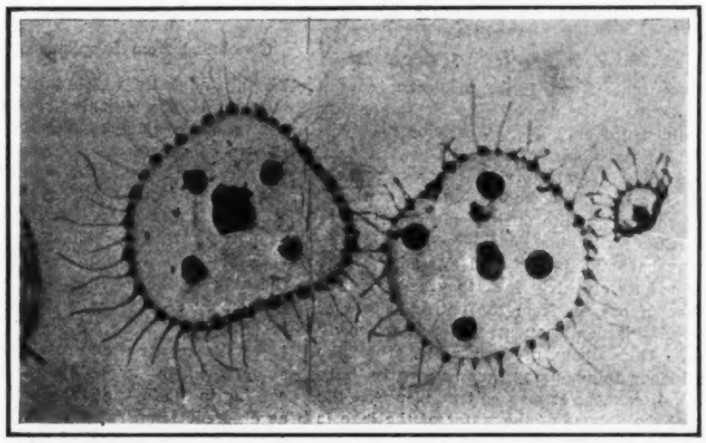
SOME CURIOUS CREATURES OF THE SEA.

BY F. MARTIN DUNCAN.

There are few more enjoyable ways of spending an afternoon, when on a visit to the seaside, than in wandering along the shore in search of ocean treasures cast up by the waves, and in exploring the rock pools left by the receding tide. Of the flotsam and jetsam collected during such a ramble, a large proportion will probably be found to consist of delicate, feathery objects, whose numerous branches have a minute serrated appearance, and are horny in texture. These fragile, plant-like objects, so often to be found enshrined in albums as mementoes of a happy holiday spent by the sea, were once the homes of innumerable graceful creatures, whose romantic life-history is one of the most striking and remarkable examples of the wonderful phenomenon of the alternation of generations that original investigation in the realm of natural science has yielded. Cast up on the sands, all glistening with opalescent rainbow hues, these graceful, plant-like objects might well at first sight be mistaken for exquisite members of the vegetable kingdom, and it is not surprising to find that at one time they were classed as such. Indeed, it was not until scientists had come to fully realize the vital importance of closely observing the living organism in its natural environment that these feathery, seaweed-like objects ceased to be a puzzle, and the cause of much fierce and wordy warfare, and at last found their proper position in the animal kingdom. Popularly known as zoophytes, these interesting creatures belong to the Hydrozoa, a division of the Cœlenterata, which also includes the fresh-water polypes, and many jelly-fish, mostly small in size. These feathery-looking zoophytes are a very numerous tribe, to be found growing on the wooden piles of piers and wharves, on the rocks and seaweeds of the tidal pools, on great whelk-shells that form the movable homes of the hermit crabs, and in most situations from tide marks to deep water. Graceful as the slender stems and spreading branches of the dried zoophytes are, one must see a specimen when it is in full life and activity, under the microscope, to be able to realize its beauty. The branches are then seen to be covered with countless tentacle-crowned polypes, so that the whole specimen appears to be a mass of exquisite, motile, rayed flowers. Some idea of how numerous are the inhabitants of a colony may be obtained from a cursory examination of a small species called *Plumularia cristata*, each branch of which may comprise from 400 to 500 polypes, the entire colony probably numbering about 6,000 inhabitants; while in larger and equally abundant species, the colony will frequently number anything from 80,000 to 100,000 individuals.



A YOUNG MEDUSA, WHOSE OFFSPRING WILL BECOME FOUNDERS OF NEW ZOOPHYTE COLONIES.



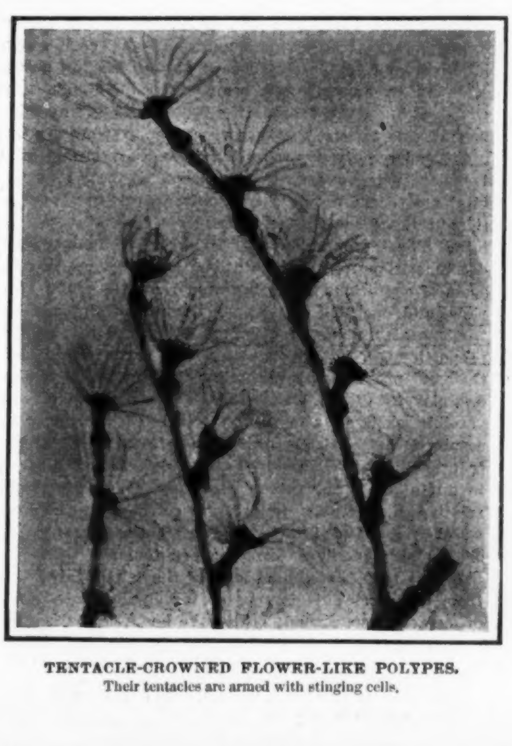
YOUNG FREE SWIMMING MEDUSÆ, WHOSE OFFSPRING WILL BECOME FOUNDERS OF NEW ZOOPHYTE COLONIES.

On examining a living zoophyte under the microscope, one sees that the branched filaments of which it is composed are covered on one or both sides with little conical, tentacle-crowned polypes, each inclosed in a glassy, cup-like investment. Each flower-like polype has a hungry, elastic mouth in the center of the waving circle of tentacles, which leads to a stomach whose base is again directly connected with the filament; for each polype contributes to the nutrition and growth of the whole colony. The circle of numerous tentacles around the mouth are employed in obtaining food, and are somewhat complex in their structure, capable of stinging and paralyzing the microscopic forms of life, such as animalcules, motile ovæ, etc., on which the polypes feed. The polypes are the sexless workers of the colony, their one function in life being to keep up the supply of food necessary for the growth and persistence of the life of the colony, which increases in size by a plant-like process of budding. Less numerous than the tentacle-crowned polypes, and to be found chiefly toward the central portion of the colony, are long transparent cases, each containing a cylindrical body bearing numerous small lateral offshoots, which, according to the stage of development they have reached, vary in form, and are called medusa-buds. During the winter, the zoophyte colony increases in size and in the number of its polype inhabitants. As the spring of the year advances the large transparent cases containing the cylindrical bodies become more prominent upon the colony, and within them a change is seen to be taking place. The tiny medusa-buds grow and change their shape, until they resemble saucers attached to the cylindrical body by the middle of their convex surface. Around the edge of each saucer some sixteen short tentacles are formed, and a blunt process is seen to project from the center of the concave surface. Eventually the transparent case which has served as a nursery is ruptured, and one by one the young saucer-shaped medusa-buds make their escape.

As they issue from their nursery we are at once able to realize why they were called medusa-buds, for now that they are free, we see that they have grown into perfect miniature medusæ or jelly-fish. They are somewhat complicated little creatures in their structure, provided with a four-sided mouth communicating with a system of canals, by means of which the digested food is distributed. The edge of the little bell, or umbrella-shaped body of the tiny medusa, is produced into a narrow shelf, from which the tentacles, sixteen in number in the newly-born jelly-fish, but very numerous in the adult, arise. At the base of certain of these tentacles are to be found curious globular sacs, each containing a calcareous particle, and at one time considered organs of hearing. Undoubtedly they are sense-organs, and in all probability they enable the medusa to judge the direction in which it is swimming. These medusæ, unlike the fixed

THE TRANSPARENT NURSERIES IN WHICH THE YOUNG MEDUSA BUDS ARE FORMED.

PORTION OF A ZOOPHYTE COLONY.



TENTACLE-CROWNED FLOWER-LIKE POLYPES.
Their tentacles are armed with stinging cells.

ZOOPHYTES.

polypes of the colony, are capable of producing young, and have the sexes developed.

The zoophyte colony, consisting of sexless polypes, can only develop by budding; but, as we have seen, it is capable of producing buds which eventually become separated from the colony as free-swimming male and female jelly-fish. The offspring of these medusæ are, unlike their parents, ovoidal in form, and more or less clothed with cilia, by means of which they freely swim. When the time comes for the medusa baby, or planula, to settle down, it fixes itself by one end to a piece of rock, timber, seaweed, or other suitable base, and becomes converted into a simple polype, having a disk-shaped attachment at its base, and at its distal end a mouth and circlet of tentacles.

It soon sends out lateral buds, and by a frequent repetition of this process becomes converted into a zoophyte colony, thus completing the cycle of the alternation of generations—first the asexual zoophyte colony developing by budding, then the sexual generation of free-swimming medusæ, whose offspring in turn become the founders of asexual zoophyte colonies.—Country Life.

THE RESPIRATION OF AN INLAND LAKE.—II.*

WHAT OXYGEN MEANS TO INLAND WATERS.

BY PROF. E. A. BIRGE.

Concluded from Supplement No. 1703, page 127.

THUS we see that if we desire to determine the capacity of a lake for the development of higher life, we must consider not only its capacity for food production, but also its respiratory conditions. It may be that an imperfect respiratory mechanism renders a very large share of the bottom of the lake wholly uninhabitable for animal life during the warmer part of the year; that while, for instance, mud-living insect larvæ may be found in the mud around the lake to a depth of twenty or thirty feet, they are excluded by the absence of oxygen from the entire bottom of the lake beyond this depth, an area of perhaps many square miles. The supply of food which the lake offers to the higher animals may thus be greatly limited by the lack of oxygen. It may be true also that the greater part of the volume of the water of the lake is uninhabitable for similar reasons, and that a lake whose surface appearance would indicate that it is capable of supporting enormous quantities of fish may be very considerably restricted in this respect by its respiratory capacity. Each lake should be studied as to both food and oxygen if an intelligent economic use is to be made of its waters; and when this is done, the possibilities of use will often be found to depend on the respiratory mechanism.

I have said nothing on another side of the methods of absorbing and transporting gases in a lake. The same processes which take oxygen from the surface bring waste gases to it and they are as efficient, or as inefficient, in the latter operation as in the former. Processes of absorption and transportation have much to do with the story of the complex relations of carbon dioxide gas in the lake. These matters, however, can better be spoken of under internal respiration. I need only say here that the accumulation of waste gases in the lower water does not seem to affect life unfavorably if there is plenty of oxygen present also. Respiratory inefficiency limits life in a lake because of lack of oxygen rather than because it allows poisonous gases to collect in large quantities.

The subject of internal respiration deals with the changes of gases within the lake itself and with the manufacture of gases by the organisms which inhabit it. No branch of physiology is more intricate and none less understood than is that of internal respiration. This is true also of the internal respiration of the lake. The gaseous exchanges and the manufacturing operations in the interior of a lake are far more complex than those of any animal. From the water living beings are drawing supplies of gas, each after its kind, and to the water each is contributing gases differing in amount and composition. Animals are withdrawing oxygen from the water and giving carbon dioxide to it. Algæ are repeating this process by night and exactly reversing it by day. Fungi and bacteria are using oxygen in the course of their internal vital activities; they are employing far larger quantities in the fermentative processes which they maintain. The innumerable chemical changes included in decomposition and fermentation, going on under all sorts of conditions, involving numerous kinds of materials, and operated by various organisms, are adding to the water, gases of different kinds and in varying proportions. The upper water, the lower water and the mud present very dissimilar fields of work to the organisms which inhabit them. It is, therefore, impossible even to attempt a picture of the internal respiration, with its countless operations, each adding to or subtracting from the sum of gases in the lake; in an intricate network of processes, consecutive, correlative and antagonistic; connected by relations which cross and interlock at a thousand points. I shall mention only a few detached topics.

I have said that the oxygen of the lake is absorbed from the air. This is true so far as the main stock of oxygen is concerned; but a lake has a second source of oxygen which is always considerable and which in certain places and relations may become important. The green plants which inhabit the lake are able to take up carbon dioxide from the water, and under the influence of light they can use it in the manufacture of starch, setting free oxygen in the process. In lakes which contain an abundance of algæ, considerable quantities of oxygen may arise from this source and this manufactured oxygen may play an important part in the vital history of the lake.

Consider the effect of the addition of this power of the algæ to the numerous factors which are affecting the supply of oxygen in the upper water of the lake in summer. If the oxygen of this region is studied, it rarely happens that the quantity found is the amount which would be theoretically expected, according to the laws of the absorption of gases by water at different temperatures. It is sometimes largely in excess of the theoretical amount, and sometimes is considerably deficient. The fact is that the amount of oxygen in the upper water of the lake is the resultant of very numerous and variable forces. The lake may or may not be absorbing oxygen from the air. If saturated, it will give off oxygen to the air as the water warms, or will take it in as it cools. Both of these processes go on somewhat slowly, and the oxygen is not given off or absorbed as rapidly as the water warms or cools. Into the water the green plants are discharging oxygen during the hours when the light is sufficiently strong; from the water both plants and animals are taking oxygen to assist their vital operations; and the process of decomposition is aiding to exhaust the stock of oxygen. Thus the amount present at any given moment will depend on the relative value of these forces; some of them positive; others negative; and all varying not only from day to day, but from hour to hour. Nor do these factors exhaust the list. The wind has something to do here; during a calm period the oxygen content of the upper water may differ from that of a stormy period. The vital condition of the successive crops of algæ, as they come and go, may determine for the time the predominance of the manufacture of starch, with accompanying liberation of oxygen, or decomposition, with partial exhaustion of oxygen. Thus the ability of the green plant to set free oxygen into the upper water may be of great value in maintaining the supply of the lake.

This power may be far more important in the lower water. If the transparency of the water and the thickness of the warm layer are such that a good deal of light can penetrate to the colder water, algæ will be able to manufacture starch in the upper part of this stratum. Thus in the region which is practically cut off from access to the atmosphere, large amounts of oxygen may be set free. There may be enough not only to serve the ordinary needs of the stratum, but the water may be saturated or even oversaturated with the gas.

I have said little hitherto of the carbon dioxide—a gas whose importance is quite equal to that of oxygen—and now can only sketch a part of its complex story. This gas plays many rôles in the respiration of the lake. It is at once the waste product of the tissue activity of plant and animal, the product or by-product of decomposition, and the indispensable food of green plants. The lake may obtain the gas from the air, and to some extent does so. Carbon dioxide exists in the atmosphere in very small amount—about four parts in 10,000. Minute as this quantity is, the land plants are able to secure from it ample supplies of carbon. The movement of the air is so free and such enormous quantities pass over the surface of the plants, that they readily pick up the gas in large amounts. But the situation of the algæ and other plants of the lake is very different, as they must secure their carbon dioxide through the intermedium of the water. This readily absorbs large quantities of the gas. But the percentage existing in the air is so small, the absorbing surface of the lake is so restricted, and the means of transport are so poor that the lake is quite unable to take from the air enough carbon dioxide to maintain a vigorous growth of plants. The lake is forced to depend on its own resources to a large degree for this plant food. Fortunately, these resources are considerable. Great amounts of carbon dioxide are manufactured in the lake and these may be utilized as food by the green plants. Thus there is kept up in the lake a sort of internal circulation of carbon dioxide; the stock of the circulating medium being increased and replenished by additions from outside. The activities of animals and the processes of decomposition liberate the gas, which is taken up and manufactured by the plants into organic substances; and these in turn serve as food and as material for new decomposition; while from the air the water may be absorbing new supplies of carbon dioxide to make good the losses of this process. Thus under normal conditions, the lake would return little or no carbon dioxide to the atmosphere, but would utilize within itself all that it manufactured or absorbed, at least until the plant life became so abundant as to be limited by other causes than that of food supply.

If this were all, the story would be quite simple and quite to the advantage of the lake. But it is by no means all the story. On the other hand, so far from being forced to solve problems associated with an oversupply of carbon dioxide, the lake has to encounter many difficulties in securing an adequate supply of that gas, and is able to meet them only very partially and imperfectly. Since the plants are able to utilize carbon dioxide in the manufacture of starch only during the hours of sunlight, considerable quantities may escape into the atmosphere during the night. But this is not the only disadvantage as regards the supply of carbon dioxide, with which the plants of the upper water have to contend. By no means all, or even the greater part of the organic matter which they manufacture decomposes in the upper, warmer stratum of the lake. As the plants and animals die, they sink into the lower and cooler water before any great part of the decomposition has been completed. The carbon dioxide which is there produced is discharged into this bottom water. It cannot be used there by plants on account of lack of light. The same imperfections of transportation which prevent the access of oxygen to the cooler water in summer make it impossible to transport the carbon dioxide produced there to the upper stratum, where it can be utilized. In certain lakes, indeed, a small portion of this gas may be used in the cooler water, as I indicated above, but, in general, the upper water, as a result of this process, is growing poorer during the summer in the materials on which plants feed, both gaseous and other. These are for the time locked up in the lower water and so withdrawn from the circulation of life. In the autumn, as the lake cools and the thickness of the circulating stratum increases, these matters become available so far as they lie in the upper part of the cooler water, and when the lake has become uniform in temperature to the bottom, and the water is turned over by wind, the whole of this accumulated stock is available for the purposes of plant growth. This may be one of the reasons for the abundant growth of algæ, which takes place in the autumn. But while the non-gaseous products of decomposition may be wholly utilized in the lake, the carbon dioxide is hardly likely to find full use. When it once becomes distributed through the water and new portions of the water are being continually exposed to the air, considerable quantities must escape during the hours when plants are unable to avail themselves of it.

Thus the rudimentary character of the circulatory apparatus of the lake forms an insuperable obstacle to the best utilization of the food supply. It is therefore easy to see why life is relatively so abundant in large and shallow lakes, in which the circulating methods have a maximum efficiency. The fact that these lakes are shallow permits a larger growth of life, since not only is the water available but plants in large quantities may grow from the bottom. But of even more importance than this relation is the fact

* Address of the president at the thirty-sixth annual meeting of the American Fisheries Society.

that since the entire mass of water is kept in circulation by the wind, all the products of decomposition are immediately available for use and the life cycles of the plants may go on as rapidly as their rhythm of growth will permit. The carbon dioxide and other products of decomposition, instead of being locked up in the deeper water and set free only during that season which is least favorable for growth, are utilized immediately and are employed over and over again through the warmer season as the cycles of life and death of the individual plants recur. It is plain that lakes whose margin is wide and shallow, though the middle may be deep, must stand next to the shallow lake in efficiency of means of transportation. Much growth takes place in the shallow waters, much decomposition goes on there, and relatively little of the organic matter sinks into the deep water, to be withdrawn from circulation. Least favorably situated is the deep and steep-sided lake, whose cold depths are continually swallowing almost all of the products of the summer's growth, and give them back for use only late in the autumn when the season for active life is passing away.

Some lakes may find aid from another source in the task of securing carbon dioxide. Most natural waters contain a certain amount of calcium and magnesium salts in solution, and, for the greater part, these exist in the form of bicarbonates. Lakes whose water is hard contain a considerable amount of these bicarbonates and soft-water lakes have little or none. In hard-water lakes it is found that during the growing season, when algæ are active, the upper water contains no free carbon dioxide, but is, on the contrary, alkaline, when tested with phenophthalein as an indicator. This alkalinity comes from the fact that one molecule of carbon has been withdrawn from part of the bicarbonates, converting them into carbonates. It appears that the algæ are able to effect this reduction and that they can obtain their supply of carbon from the carbon dioxide of the bicarbonates dissolved in the water. This fact introduces a wholly new feature into the story of the food supply of the plants. It provides a chemical carrier for the carbon dioxide which may carry this gas somewhat as the hemoglobin carries oxygen in the blood. All carbon dioxide set free in this alkaline water as the result of decomposition or other processes will be taken up immediately by the carbonates. Thus if plants are not at hand to utilize the carbon dioxide at once, it is not lost, but kept until it is needed. So in the night, the lake is able to retain all the carbon dioxide set free and which the plants do not use at that time.

Such alkaline water has also a great advantage in absorbing carbon dioxide from the air. It presents for absorption, not merely the relatively weak and slow powers of the water for dissolving the gas, but the eager and vigorous powers of chemical affinity. And until these alkaline carbonates are saturated, no free carbon dioxide will appear in the water to diminish the rapidity of absorption from the air. Thus hard-water lakes have an advantage over soft-water lakes in the matter of securing plant food, and in fact the population of soft-water lakes is smaller than that of lakes of the other type.

It is worth while to devote a few words to gaseous products of decomposition other than carbon dioxide. So long as the bottom water contains an abundance of oxygen no other gas than carbon dioxide is produced in appreciable quantities. But as the oxygen becomes greatly reduced or wholly disappears, decomposition continues in new forms and under these conditions of anaerobic fermentation other gases may be developed in considerable amounts. It is apparently true that carbon monoxide may be present in the lower water of lakes in appreciable quantity, and it is certain that marsh gas is developed in large volumes in lakes where the amount of fermentable material is large and where the oxygen disappears from the lower water early in the season. These gases first appear near the bottom, where decomposition is going on most actively and where the oxygen first disappears. In many lakes they are found only in small quantities and close to the bottom, but in proportion as the amount of decomposable matter increases, they are found at considerable distances from the bottom, and in certain lakes all the water below the thermocline may contain marsh gas in appreciable quantities, often becoming very great as the bottom is approached. These gases do not seem to have any very definite unfavorable effect on the life of the lake. Diffusion is so slow that they do not reach the upper water, and experiments indicate that their presence in the lower water adds little, or nothing, to the unfavorable conditions brought about by the absence of oxygen.

It should be noted that these processes involve a loss of material for plant food. Carbon dioxide, produced by aerobic decomposition, is available for plant food in the lake, or, if not there, then elsewhere as part of the general stock of that gas in the atmosphere. But marsh gas has no such relation to plants and all substances converted into it are lost to the cycle of life. Its production means just so much reduction of the food supply of the lake. The same may be said of the carbonized, peat-like substances produced from the partial decomposition of plants under water. So long as these remain under water, they are practically withdrawn from the food supply. Against all these influences which tend to diminish the stock of food for its inhabitants, the lake is contending, but with imperfect means and only partial success.

I have thus hastily and imperfectly sketched the respiration of an inland lake, not because the story is known with any fullness or completeness, but partly because our present knowledge, imperfect though it is, shows that the subject is one of great scientific interest; partly also because many practical hints regarding the utilization of lakes in fish culture can come from our knowledge of respiratory conditions. We are accustomed to think of the food-producing capacity of the lake as the factor which determines the kind and amount of the crop of fish which it can produce. It is a somewhat new thought to me, and I have no doubt that it is equally new to many of you, that the respiratory capacity of the lake may have even greater influence in this matter than has the capacity for the production of food. Yet it is plain that such is the case and that a knowledge of the respiratory conditions of the lakes in which our fish are to be planted is necessary if the best results are to be reached.

A SOFT COAL FIRE.*

THE CHEMISTRY OF COMBUSTION.

BY PROF. VIVIAN B. LEWES.

In the south of England the domestic grate using bituminous coal is the principal cause of the smoke cloud which, hanging over the big towns, cuts off the direct rays of the sun, ruins health, shortens life, kills vegetation, and begrimes and finally helps to destroy public buildings. Further north in the manufacturing districts the factory shafts, in spite of restrictive legislation and mechanical improvements in stoking, do even more toward polluting the atmosphere.

Many estimates of the relative amount of pollution due to manufacturing works and domestic fuel have been made, but as the question of what is the ratio of smoke production from the various sources that pollute the air varies enormously with the locality, no very satisfactory conclusion has been arrived at.

If you take London, Dr. Shaw's estimate that 70 per cent of the smoke is domestic would probably be about correct, but if you collected your statistics in Sheffield or Birmingham, the figures would most likely be reversed. There is one thing certain, however, and that is that domestic smoke is produced throughout the whole length and breadth of the land, while the factory shaft concentrates its attention on the more limited area of the manufacturing districts.

Although the smoke from the domestic chimney has been execrated for the part it has played in the pollution of the atmosphere from the earliest years of the fourteenth century down to the present day, it is surprising how crude the ideas are that exist as to its composition and the method of its production. In the open fire the radiant heat given by the incandescent fuel is the heating agent, and although undoubtedly wasteful in fuel, owing to the largest proportion of the heat escaping with the products of complete and incomplete combustion up the chimney, still is so far more hygienic and more comfortable than any other method of heating that one would be sorry to see its place taken by any other form of heat production, in spite of the economic advantages of central heating systems, or slow combustion stoves.

With the ordinary grate, using bituminous coal, the production of smoke means waste of fuel, but great as this is in the aggregate, it is small as compared with the other losses due to actions taking place in the fire itself, and loss of heat escaping up the chimney. When bituminous coal is fed on to the burning fire, the action which takes place is practically the same as that occurring during the distillation of coal, and it is during this period that a very large proportion of the heat latent in the coal is lost, owing to the amount taken up in decomposing the coal and converting the volatile portions into vapors and gases. During this period you have the coal, heated by the fire from below and comparatively cool above, distilling off tar vapors, coal gas and steam, in about the same proportions as they are emitted during the destructive distillation in the gas works. In the early stages, the surface of the fuel being too cool to lead to their ignition, they escape as vapors up the chimney, mingled with anything from eight to thirty thousand cubic feet of air per hour, according to the draft in the chimney. In an ordinary flue an analysis of the escaping products would give an approximation to the following:

Carbon dioxide	0.70
Methane	0.36
Hydrogen	0.29
Carbon monoxide	0.01
Oxygen	19.85
Nitrogen	79.79

During this period of smoke production no soot is formed, and the physical properties of the cloud of vapor form an interesting study, as it explains one of the secrets of the lasting power of smoke and the way in which it acts. A puff of such smoke blown through a small glass cell illuminated from below by oxy-hydrogen or arc light, and examined under a low-power microscope, reveals the fact that this form of smoke consists of excessively minute vesicles, which are in a marvelous condition of motion, and which will remain floating in the stream of air or gas until impact with a solid surface causes a bursting of the little liquid envelope, forming a microscopic drop of tar on the solid against which it has struck, and liberating the contained gases.

This period is the one in which the most serious waste takes place, as not only is the greatest amount of heat being rendered latent by the distillation out of the coal of these products, but you also have them escaping unburned up the chimney. After a period, which varies in length according to the amount of coal which has been fed on to the fire, sufficient heat finds its way to the top of the fuel to ignite some of the escaping vapors, and the bright illuminating flame is then formed above the surface of the fire. This flame radiating a considerable amount of heat owing to the incandescent particles within it, the waste ceases to be as great as before, but a large amount of vapor will be noticed to be still escaping unburned, owing to some of the hydrocarbons being so diluted by steam and the cold air sucked in over the surface of the fire as to stop their combustion.

If now the flames themselves be watched, it will be seen that they become red and lurid toward the top, and are emitting particles of carbon. It is during this period of combustion that soot is deposited in the chimney and appears in quantity in the smoke, which now consists of tar vapor, soot, water vapor, products of combustion, and excess of air, together with the residual nitrogen from that portion of the air which has been used in the combustion, and also particles of ash sucked up by the draft in the chimney.

As time passes on the fire burns clear, the amount of flame becoming extremely small and consisting chiefly of carbon monoxide, and practically smokeless combustion is attained. Until more coal is fed on no further pollution of the atmosphere takes place, while the clear fire radiating out the heat given by the combustion of the incandescent carbon is doing more heating work than at any other period.

In order to overcome the trouble of smoke while using solid fuel, many forms of grate have been suggested, the most successful of them being dependent upon the principle of feeding the fresh fuel to the bottom of the fire instead of to the top, so that as the tar, hydrocarbon vapors, and steam distil out from the coal, they have to pass through a mass of incandescent carbon above, which decomposes the complex tar vapors into simple hydrocarbons. These are then completely burned up on reaching the fresh air supply at the top of the fuel.

The fact, however, that any special form of grate would require the removal of the old type and intro-

* Abstracted from the Journal of the Society of Arts.

duction of the new, has been sufficient to prevent any success in such directions, and what is really needed to make smoke prevention a practical possibility is the introduction of fuel which could in every way be treated like coal, which would be as easy to ignite, would burn with a cheerful flame, and would in reality commence its combustion just at that period when in a fire the smoke has ceased and the fire burned clear.

I have always been strongly of opinion that the only way in which the smoke problem could be solved was in stopping the direct combustion of bituminous coal in grates and furnaces, and employing the gas works of the country to convert it into gaseous and solid fuel, both of which would give smokeless combustion, at the same time extracting in useful form those volatile products which, in the manufacture of gas, yield tar, but in the stove or furnace form smoke.

THE TRANSFORMATION OF HEAT INTO WORK.

THE CONVERSION OF VARIOUS FORMS OF ENERGY GRAPHICALLY DESCRIBED.

BY PROF. SIDNEY A. REEVE.

FALLING water may perform work in either of two ways—by its pressure or by its momentum. Fig. 1 shows a reservoir having a piston at the bottom apparently about one-fourth the area of the stand-pipe. Let us suppose that the stand-pipe contains 400 pounds of water. Then the pressure on the piston would be one-fourth that on the bottom of the pipe, or 100 pounds. Let the piston be permitted to move out by the volume of one pound of water, then 400 pounds have fallen by one four-hundredth of the height from the water level to the pump cylinder. The work done is plainly that of one pound of water falling the entire distance. The piston would move out one-hundredth of the same distance, or "head," of water. Its work would be one-hundredth of 100 pounds times the entire distance, as before.

In the same way it can be shown that in the accompanying Fig. 2 the water issuing in a horizontal jet would strike the wheel with the same velocity and energy as if each pound of water fell freely through the air for the entire height and struck the wheel tangentially at its right-hand side. Imagine each pound of water to be permitted to act in this way separately. A single pound of water is placed in the top of the reservoir. Then a pound's worth of work is drawn off at the bottom. Then the pound of waste water is thrown away. Then a fresh pound of water must be placed in the top of the reservoir, if the supply of power is to be continuous, and so on.

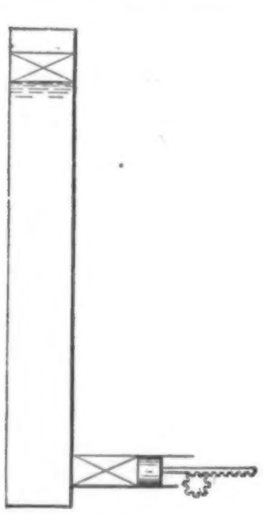


FIG. 1.

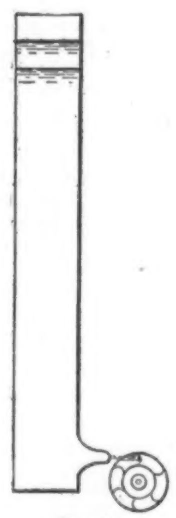


FIG. 2.

This general process can be usefully represented by a diagram such as Fig. 3, wherein the height of fall of the water is represented vertically and the weight of the water is shown horizontally. Thus, if any weight of water W be taken into the system at the level H_1, be then permitted to fall, doing work, to a lower level, H_2, and be there discharged, the work done will be

$$\text{Work} = W\,(H_1 - H_2).$$

It is to be noticed here that the third process is just as important as is the first. A water-wheel will no more work properly with a choked tail-race than it will with a poor water supply. It should also be noted that the pound of waste water must somehow be put back into the reservoir, some time or other, if things are to work continuously. The sun performs for us a similar task by evaporating sea water into clouds and raining it on the hill-tops again.

Fig. 4 shows the form in which this work appears upon the piston. The preliminary filling of the reservoir, before the machine started, produces the pressure P_1 on the piston. This process is shown by the line IV. When the pound of water is admitted the piston moves out by the distance D. This is the process I. Then the supply is cut off and the exhaust is opened. The pressure falls, resulting in the process II. The piston is then returned against the smaller resistance P_2, making the process III.

The net work done is $(P_1 - P_2)D$.

A four-faced series of processes such as this is called a cycle. It always consists, first, in biting off, so to speak, a piece from the general stock of supplies. The size of this "bite" is measured by the width of the diagram.

Secondly, this "bite" of stuff and energy is permitted to fall down what is called the intensity of its energy. In mill-pond energy this intensity is vertical height, measured in feet. In the energy of general fluid-pressure lines, such as hydraulic systems or compressed-air conduits, or in piston-rod pushes and the like, wherever the energy acts purely mechanically, this intensity of energy is the force or pressure available.

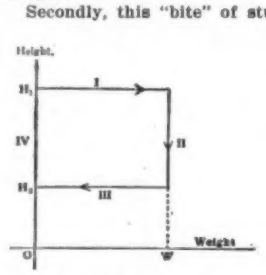


FIG. 3.

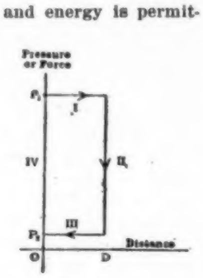


FIG. 4.

Thirdly, the "bite" of energy, having given up its intensity and lost its availability for further work, has become waste and is thrown away or exhausted.

Fourthly, the machine is made ready to repeat the process.

One very important form of cycle is that of the energy of motion, as in the hydraulic jet striking the wheel. This is illustrated in Fig. 5, showing the action in the wheel of Fig. 2. In the case of motion-energy the intensity of the motion is properly measured, not by its velocity, but by one-half the square of the velocity, stated in feet per second. Why this is so we do not know. The vertical dimensions of Fig. 5, therefore, exhibit the velocity of motion, squared and halved.

The size of the "bite" involved in motion-energy is measured by the mass which is in motion. The mass of a body is found by dividing its weight at sea level by 32.16.

When the water approaches the wheel of Fig. 2, it possesses the intensity of motion, $\frac{1}{2}V_1^2$. A unit mass of water enters the wheel with this motion. This is the process I of Fig. 5. Then the mass strikes the curved and moving vanes of the wheel. Its motion is lost; not by impact, producing heat, but by a gradual and oblique diversion, whereby work is done. This is the process II. Then the waste water is discharged, forming the process III, which obviously cannot take place if the velocity has been reduced to zero. Finally, a succeeding "bite" of water gets up velocity, ready to get into the wheel and strike the next vane, which is the process IV indicated on the diagram.

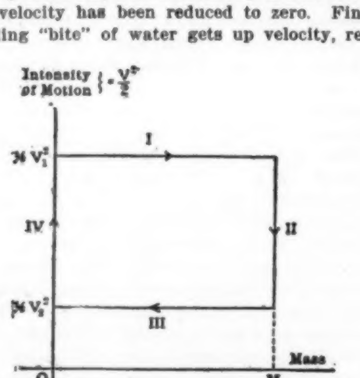


FIG. 5.

Cycles such as those drawn are called direct. They always develop and give out power. They are illustrated by diagrams with arrow-heads making the circuit in a clockwise direction. Suppose the arrow-heads of Fig. 5 to be reversed. It will then illustrate the action of the nozzle of the turbine, whereas before it showed the action of the wheel. For the nozzle or guide-blade of a turbine is an energy-transforming machine of no mean importance, especially in these days of steam turbines.

The nozzle receives one pound of water, say, at a low velocity (Process III reversed). The converging form of the nozzle raises the velocity (Process II reversed). The water is discharged from the nozzle at high velocity (Process I reversed). Another "bite" of water is then taken into the nozzle. Such a cycle is called a reversed cycle. It always absorbs power. It is illustrated with diagrams in which the arrows complete the circuit in counter-clockwise direction. Every clockwise cycle must develop a counter-clockwise cycle, and *vice versa*. Thus, the first cycle in our chain was that of Fig. 3, a direct one, or the cycle of the penstock. This cycle developed in the nozzle the reversed cycle of Fig. 5 reversed. This developed again in the vanes of the wheel a new direct cycle, that of Fig. 5 as it is drawn. The power issuing from the water wheel again develops new reversed cycles, which it is not our business to follow here, and they again develop further direct cycles.

The series of cycles acts like a chain of clocks which might be imagined so arranged that each one, in running down, wound up its next neighbor. The second clock, being set when wound up, would pass on the energy to the third clock, and so on. In each clock would occur first a reversed and then a direct cycle.

Fig. 5 is the first of the diagrams which will make plain what is meant by the efficiency of a cycle. In

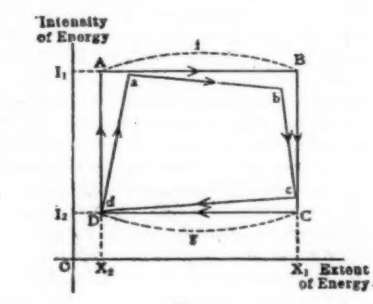


FIG. 6.

that cycle, whatever intensity of motion the water possesses as it leaves the wheel is a direct source of loss. The energy put into the water in the process IV, and taken into the wheel in the process I, is measured by the area beneath that line down to the zero axis, or $\frac{1}{2}M\,V_1^2$. The energy taken up by the wheel is $\frac{1}{2}M\,(V_1^2 - V_2^2)$. Therefore the efficiency of transformation is

$$F = \frac{V_1^2 - V_2^2}{V_1^2} = \frac{I_1 - I_2}{I_1},$$

wherein I is the intensity of motion, or $\frac{V^2}{2}$. This efficiency in an actual water wheel is always less than unity; for we cannot get the water away from the wheel and at the same time have its velocity zero.

The same is true of a water-piston. There must always be some head, or intensity of height, left in the water, or it would not leave the cylinder when the exhaust is opened. Indeed, this "remnant" of intensity is always, in actuality, the entire fall from the machine to the sea level, which is considerable; but it is not usual to take this into consideration.

Suppose, now, that we consider the diagram of an actual machine, instead of a theoretic one. Such a diagram would be Fig. 6. It can be read for either height-energy, pressure-energy or motion-energy, for the axes are labeled only for intensity of energy and for extent of energy, as we call the size of the "bite," respectively.

The energy is supplied at the upper level I_1 and can be discharged to the lower level I_2. But some loss of

intensity is involved in getting the working substance into the machine. If it be a water wheel, some head is lost between the mill pond and the wheel, or some intensity of motion is lost in friction. The wheel receives the energy not along the line *A B*, but at a lower level of intensity *a b*.

Or perhaps, as might be the case in Fig. 1, the reservoir has to be filled before pressure can be accumulated, requiring, say, one-sixth of each "bite" of water to get up pressure. This would be shown by the line *d a*.

We should get this same sort of a line in the nozzle-diagram, if the nozzle were made of rubber, so that it had to be stretched, as each pound of water reached it, before full velocity could be attained.

Again, if the piston leaked, or the water wheel vane had a hole in it, some of the "bite" would get down to exhaust conditions before the work were all done. This would be shown by the line *b c*, showing a "leak." Finally, the machine might not exhaust freely. The water would be driven out while still having more motion or more pressure than is theoretically necessary. Such action would be shown by the line *c d*.

In all these cases there is a free fall of the energy "down intensity." As the "bite" *A B* enters the machine it falls freely, without doing work, from the level of supply to the various levels of *d a b c*. As it leaves it falls freely from the levels of *c d* to the level of exhaust *C D*. All such free fall constitutes loss of efficiency. It is plain that the actual cycle can never exceed the theoretic rectangle. Water supplied at the *A B* level would never enter the machine at the levels of *A f B*, for instance. It will not flow "up intensity" from *A B* to *A f B*. Nor could any machine exhaust from the levels of *C g D* up into a tail-race at the *C D* level.

Consider now an actual reversed cycle, as in Fig. 7. Such a cycle must always exceed its theoretic rectangle, just as the actual direct cycle must always lie inside. The energy *D C* will not enter the machine except at some lower levels, such as those of *D g C*. It will not leave except by some higher levels, such as *B f A*. Such an action is as inefficient as would be that of a hod-carrier who, when told to carry bricks from the street to the fourth floor of a building, should first go down into the cellar with his hod, drop the bricks into the hod from the street level, then carry it to the fifth floor and dump the bricks back to the fourth floor. Yet the hod-carrier must perforce do some such things as that, at least to the extent of a few feet, if he is to get his bricks into and out of his hod automatically. The bricks will get into his hod of themselves if he lets them slide down a chute; and will get out again in the same way. All of our pumps, grain elevators and refrigerating machines work in this way, going below the level of supply to be charged and discharging at a higher level than the waste-carrier. And all of these machines work upon reversed cycles, absorbing power in order to pump energy "up intensity." In the refrigerating machine it is the energy which we are after. We wish the beef cooled. We care little what carries the heat "up temperature" out of the beef. In the grain elevator it is the grain we are after; we care little about the energy in it. In the pump it may be either the substance or the energy which is wanted. In all cases the principle of operation is the same.

It is now plain that a direct cycle has a better efficiency the bigger it is; yet it may never exceed its rectangle. The reversed cycle, on the other hand, is the more efficient the smaller it is; yet it may never be smaller than its rectangle. Plainly, therefore, the rectangle is the limiting form of maximum efficiency for either direct or reversed cycles, between any given pair of limits in intensity. With this fact firmly fixed, and remembering that the efficiency of any rectangular cycle is given by the expression $\dfrac{I_1 - I_2}{I_1}$, we are equipped to understand better how heat performs work.

The first fact to be understood about heat is that temperature is its factor of intensity. Heat always tries to get "down temperature" just as persistently as water tries to get down hill. It will flow from a hot body to a cold whenever it gets a chance. If we put a machine of the right sort, such as a steam engine, between a hot body such as a steam boiler and a cold body such as a condenser, the heat will do work as it flows "down temperature," from boiler to condenser, just as the water wheel set between the head-race and tail-race will do work.

If temperature be the intensity of heat-energy, what measures its extent?

In the forms of energy with which we are more familiar we can measure directly all the factors, such as height, weight, pressure, distance, velocity, mass, etc. By multiplying the proper ones together in pairs we get a measure and an understanding of their energy.

With heat, however, we have to reverse this rule. We can measure heat-energy directly, in B. T. U. We can measure temperature directly. When we impart a heat unit to a substance we may divide the heat imparted by the absolute temperature at which it is imparted. The result corresponds exactly to the dividing of height-weight energy by height, giving weight as the result, or of dividing motion-energy by intensity of motion, giving mass. In the case of heat this dividend is the extent of the heat-energy involved. It is the "heft" of the heat, being to the heat just what the mass of the hammer-head is to the blacksmith's blow. It is, indeed, the true mass of the heat. It embodies the portions of the mass of each molecule which are separated from the body of the molecule to take

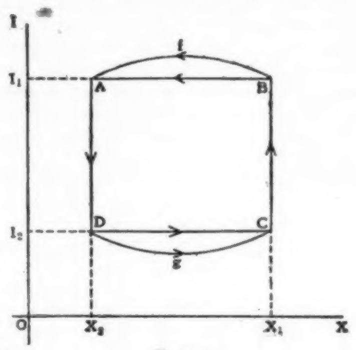


FIG. 7.

part in the heat-energy. When the body radiates its heat these portions recombine with the body of the molecule. This is just as a lump of water, or a cannon ball, or a railroad train temporarily separated from identity with the earth in order to contain energy, recombines with the earth when the energy is gone.

This subdivision or comminution of the mass of the molecule in heat-motion is called entropy. It is of the same importance in heat action that mass is in mechanics. Neither of these quantities can we perceive directly; yet we cannot compute nor understand any natural action without them.

In thinking of these matters we must not imagine a molecule as a solid sphere, or anything like that. A molecule is an exceedingly complex body. As bodies grow hotter increasing portions of the molecule's mass separate from the central nucleus to take part in the outer orbits of the motion which we call heat. If we could ever get any substance into the condition described as a "perfect gas" the central nucleus would be all gone, all split up finely into freely moving fragments. If we could ever get any substance absolutely cold and solid, at 461 degrees below zero Fahrenheit, the molecule would be completely consolidated into its solid nucleus. But neither of these states has ever been attained in matter; and we now know, from mathematical considerations, that they never can be attained.

It is the orbital portion of the molecule only which takes part in heat-motion.

Let us now start with one pound of water at 32 deg. F. to heat it and to draw on paper a picture of what we have done. Fig. 8 will be the picture, with *A* for the starting point.

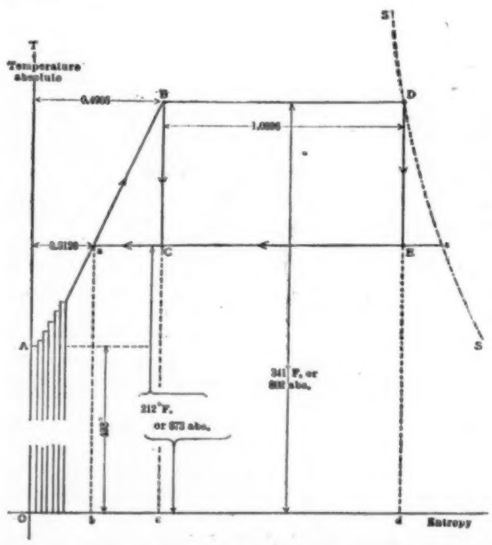


FIG. 8.—THE ENTROPY DIAGRAM FOR STEAM.

The first thermal unit added is given at the temperature of 461 + 32 = 493 deg. F. absolute. The entropy involved is therefore 1/493 = 0.0020285. For the next unit the water is one degree warmer and the entropy is 1/494 = 0.0020245, and so on. Each of these additions of heat, therefore, may be exhibited as a tall, narrow rectangle running up from the axis of absolute zero of temperature. Each represents a fresh "bite" of mass taken off the molecule and set into orbital motion; and as the intensity of motion becomes greater the additional mass required to embody a unit of energy naturally becomes smaller and smaller. That is to say, the entropy per degree rise in temperature becomes less and less.

Remember that the water itself has nothing to do with absolute zero. Nevertheless, our picture will not be true geometrically unless each little rectangle rests on the zero axis of temperature.

The entropy values found by the simple arithmetic given above are not quite correct. Correct values will be found in Peabody's or Reeve's "Steam Tables."

By the time the point *a* is reached the temperature has become 212 deg. F., let us suppose. The entropy will then be 0.3126. But let the water be in a boiler under the pressure which has been used in the other illustrations, 120 pounds absolute per square inch. More heat can then be added and more entropy developed until the temperature has become 341 deg. F. and the entropy 0.4906.

Now exists equilibrium between the molecules trying to expand and the boiler shell holding them in. As long as the shell is as hot as the steam it can abstract no heat from the steam. As long as it stands still it can abstract no work. So the steam perforce stays in the condition *B*.

Now suppose that the boiler shell should give way. What happens? No heat is abstracted, as before, for there is no time for that. But work is now suddenly abstracted. The molecules are bombarding the shell. If a boy bombards the end of a freight car with base balls, so long as the car stays still no work can be done by the bombardment; and the balls, if perfectly elastic, come back to the boy as "hot" as he sends them in. But if the car be moving away from the boy the bombardment contributes work to it; and the balls now return to the boy with their velocity diminished by twice the speed of the car.

It is just so when the boiler shell retreats before the bombarding of the steam molecules. The accelerating retreat of the shell permits it to take up work from the molecules. It does so by robbing them of the intensity of their motion.

But there is nothing about the process to tend to consolidate either the base balls or the molecules. Their number and their mass remain the same. Therefore the heat-energy, in exploding the boiler, gives up its intensity of energy at constant mass or entropy. It drops down the plumb-line *B C*. When it reaches *C* it has to stop because the momentum of the molecules then just equals atmospheric pressure (as the steam tables tell us), and they can contribute no more energy to the boiler shell.

How much energy has the hot water developed by its explosion (for nothing has been said yet about steam)? Plainly, the difference between its stocks of heat before and after exploding.

Areas measure heats. The water's original fund of heat was measured by the area beneath *A B*, down to the zero axis. Its fund after explosion is measured by the area beneath *A a C*. The difference is the triangle *a B C*.

The area of this last can be computed most easily by subtracting from the heat put into the water (from feed-water temperature), or the area *b a B c*, the rectangle *b a C c*. The height of this rectangle is 673 degrees. Its width is 0.4906 — 0.3126 = 0.1780. The area is therefore 673 × 0.178 = 119.8 B. T. U.

The heat put in between *a* and *B* is, by steam tables, 131 B. T. U. The difference between 131 and 119.8, which has gone into work by bombarding and propelling the retreating boiler-plates, bricks, etc., is 11.2 B. T. U. = 8,714 foot-pounds per pound of hot water released.

Few engineers can perform this simple computation. One of the best boiler text books published in this country computes this result just eleven times too great.

Suppose, however, that the boiler did not explode. Suppose that when the pound of water reached the condition *B*, it began to boil into steam. As it did so it pushed back the steam above it; the pressure was transmitted through a pipe to an engine cylinder, and there pushed out the piston, doing work.

Why is not this just like the boiler explosion? Because now the phenomenon takes place so slowly that the boiler pressure can be kept up. The engineer-in-charge is careful to provide that the piston shall not draw on the boiler for work faster than the boiler can supply steam and at the same time maintain pressures constant; whereas in a boiler explosion the flying pieces take up all the work they can get, at the expense of the steam pressures—which many engineers permit to drop scandalously during boiler explosions.

So in the present case, instead of the boiler's exploding, the water molecules explode. They pop into steam, one after another, as fast as each gets hot enough, quite after the manner of pop-corn in a popper, each one bursting suddenly into more than two hundred times its original volume. Only, whereas the popcorn, once popped, is pop-corn forever, the molecules of steam may be turned back into water at any time, by sufficient cold and pressure. They may be

condensed and re-popped into steam any number of times, without wearing out.

Each molecule pops into steam at constant temperature and at constant pressure; only the volume is increased. The stock of heat is also very much increased, although the temperature does not rise. Each molecule takes up a large stock of latent heat. The entropy, or the orbital mass of the molecule, is greatly increased during explosion into steam, as might be expected. By the time the entire pound of molecules has popped, 873.7 B. T. U. of latent heat have been absorbed. This has happened at a temperature of 802 degrees absolute. The entropy involved is therefore $873.7 \div 802 = 1.0896$. These entropy values for steam can be found in Reeve's "Steam Tables."

On the diagram, the latent heat is measured by the rectangle $c\,B\,D\,d$ and the entropy by $B\,D$. The steam is now dry saturated, at the condition D.

If the same construction should be performed for a number of different boiler pressures we should get a number of points like D, which would together form the saturation curve $S\,S$. It is particularly to be noticed, however, that the saturation curve does not represent a process. No single process is known by which saturated steam of one pressure can ever be altered into saturated steam of any other pressure.

The pound of water being now all steam, and having pushed a pound of steam into the cylinder as the piston moves out, let us cut off this last pound from its fellows, by closing the admission valve, and let it work on the piston by its own elasticity. What happens?

Now we have the boiler explosion again. That is to say, we have the abstraction of work without the abstraction of heat; for we suppose the cylinder walls to be non-conducting. Only now, instead of its being a pound of hot water exploding, it is a pound of equally hot dry steam.

The energy drops "down intensity," as before, down the plumb-line $D\,E$. When it gets to E it can no longer push the piston effectively, because the opposing atmospheric pressure now just balances it. So the pound of steam has become waste, and we throw it away or exhaust it.

How much work has it done? The difference between the heat it originally had and what it still has at E. What it had at D was the area $O\,A\,B\,D\,d$, or, by steam tables, 1185.5 B. T. U. What it has at E is the area $O\,A\,a\,E\,d$. The difference is the area $a\,B\,D\,E$, or that of the cycle, as might be expected. The heat put in was that at D minus what it had at a, or $1185.5 - 180.8 = 1004.7$ B. T. U. The heat to be abstracted from the condition E in order to get the steam back to condition a is the rectangle $b\,a\,E\,d$, or the height 673 times the width $a\,E$. The latter is $0.4906 - 0.3126 + 1.0896 = 1.2676$, and $673 \times 1.2676 = 852.8$ B. T. U., or the area $b\,a\,E\,d$. The area $a\,B\,D\,E = b\,a\,B\,D\,d - b\,a\,E\,d = 1004.7 - 852.8 = 151.9$ B. T. U. = 118,17 foot-pounds.

This is the utmost work possible to be had from a steam engine using saturated steam of 105.3 pounds gage pressure and exhausting into the atmosphere, even if of ideally perfect construction.

One horse-power-hour amounts to 1,980,000 foot-pounds, or 2,545 B. T. U. Such an engine as the above should therefore consume $2{,}545 \div 151.9 = 16.754$ pounds of steam per horse-power hour. If it actually consumes say 28 pounds, it is doing only $16.754 \div 28 \times 100 = 59.8$ per cent of what it ideally could do. This last figure alone is the measure of the skill with which the designer has done his work. It is called the cylinder efficiency, or the diagram factor.—Power.

FUNGI AND THEIR CURIOSITIES.*

A SIMPLE ACCOUNT OF THEIR VALUE AND USES.

BY SANFORD OMENSETTER.

IN all the fields of botanical research there can be no more interesting subjects than the fungi, which comprise cellular, flowerless plants, nourished through their spawn or mycelium; living generally above ground and propagated by spores of various colors. They are closely related to algæ, but grow in different situations—in green pastures, in meadows and woodlands, on decaying trees; some on cereals, potatoes and other vegetation, which they destroy; others on books in damp situations, and some on man or animals under certain conditions.

The spores correspond to the seeds in other plants, but differ from the latter in being composed simply of cells and not containing an embryo. Under favorable conditions the spores develop into the spawn or mycelium, which is the vegetative part of a fungus and consists of inconspicuous white down and strings, and may be either filamentous or cellular.

Almost every earthly thing is liable to be infected by this ubiquitous race. Some spread themselves over our fruits; others attack our bread, cheese, pickles or other manufactured articles of food. "When our vinegar becomes mothery," writes one observer, "the cause of the mischief is a fungus; if pickles acquire a bad taste, if catsup turns ropy and putrefies, the fungi have a hand in it all. Their reign stops not here—they even prey on each other. The close cavities of nuts occasionally afford concealment to some species; others like leeches stick to the bulbs of plants and suck them dry; some (the architect and ship builder's bane) pick timber to pieces as men pick oakum. One variety has a particular fancy for the hoofs of horses and the horns of cattle, sticking to these alone. The body of the domestic fly is liable in autumn to be attacked by a parasitic fungous growth."

The word fungi has been adopted into the English language directly from the Latin, though originally from the Greek *sponggia*, a sponge, doubtless in allusion to their texture.

The members of the fungus tribe are similar in structure, and form an important and most remarkable division of the vegetable kingdom. Many of the species are exquisite in shape and coloring, while others are extremely valuable as articles of diet or of medicine.

In the programme of the world's development, fungoid growths have been found as early as the carboniferous period, or coal age.

The chemical structure of fungi is said to be the most highly animalized; or, in other words, to partake more of the nature of animal composition than that of any other vegetable. Besides the intimations of this circumstance that are afforded by the smell of some of the species in decay, which partakes much of the character of that of putrid meat, and the strong, meat-like flavor which some of them possess when cooked, we find the following fact stated—that, "like animals, they absorb a large quantity of oxygen and disengage from their surfaces a large quantity of carbonic acid; all, however, do not exhale carbonic acid, but in lieu of it some give out hydrogen and others azotic gas (now known as nitrogen). They yield, moreover, to chemical analysis the several components of which animal structures are made up; many of them, in addition to sugar, gum, resin, a peculiar acid called fungic acid,* and furnish considerable quantities of albumin, adiposine, and osmazome, which last is that principle which gives its peculiar flavor to meat gravy."

Crystals of calcium oxalate are to be met with on the surfaces and in the intercellular spaces of many of the larger fungi.

Chemical analysis of the cell membrane shows that it possesses the elementary constituents of cellulose; but since the uncolored and unthickened membrane does not commonly exhibit the characteristic reaction of cellulose toward iodine† nor toward many of the reagents commonly used in testing typical cellulose, it is necessary to apply to it the special term fungal cellulose.

A great distinction between the fungal cell and other vegetable cells is that the former is wholly destitute of chlorophyl. Chlorophyl is the essential constituent that imparts the green coloration to the leaves and stalks of plants. Its nature is still doubtful, never having been obtained in a perfectly pure condition.

George Murray states: "In their mode of life fungi are controlled by this absence of chlorophyl. Without it they cannot assimilate, and are therefore driven to obtain their nourishment by taking up the carbon compounds assimilated by other organisms. Their mode of life is either parasitic or saprophytic. As parasites they inhabit the bodies of living plants and animals, and even of other fungi. In some cases they kill their hosts, and in others encourage growth, as in the case of the lichens,‡ and between those two extremes various degrees of parasitism occur. As saprophytes they promote the decomposition of dead organic bodies, and thus aid in the production of carbonic acid, water and ammonia, the elements of which return to the course of organic life."

Jodin relates that some fungi absorb as much as six per cent of their nitrogenous content in the form of nitrogen gas from the atmosphere. In the decomposition of fungi, ammonia is formed from the nitrogenous compounds. As parasites and saprophytes their influence as regulators in the economy of nature may be compared with that of the lower animals living the same mode of life.

Of more immediate interest are the esculent fungi. Of these by far the greater number are comprised in the family of Agarics, a division which takes its name from Agaria, a region of Sarmatia. Our English word mushroom, by which all kinds of edible fungi are commonly designated, has a French origin and comes from the word *mousseron*.

Among one thousand American fungi described by Charles McIlvaine, some seven hundred are catalogued as fit to be eaten, having more or less commendatory flavors, while less than a dozen are fatally poisonous. With most persons, but one species, the well-known meadow mushroom, is worthy of confidence. Their creed is expressed in the quaint words of the old herbalist, Gerard, who said,

"The meadowe mushroom is in kinde the best;
It is ill trusting any of the rest."

And yet, by those living in the country, what teeming wealth of nutriment is allowed to go to waste because of lack of knowledge.

It is a pleasant thing to sally forth early in the day, under the first burst of sunshine which breaks out on a soft, clear morning in September, and to see how the night dews have been at work hastening the growth of fungi.

We need hardly say that mushrooms are excellent pickled. The way to preserve them is to select all the buttons; place them, skins and all, in a stewpan with allspice, salt and pepper; stew them until they have given out every drop of their juice and have reabsorbed all those juices, charged with the flavor of the spices among which they had been stewing. When this process is completed, add as much hot vinegar as will cover your mushrooms, boil them just for a minute, and they are finished. The large, broad specimens are delicious broiled with salt and pepper, and the middle sized kinds stewed in their own juice, with a little pepper, salt and butter.

Throughout the continent of Europe plants of the fungus tribe are eagerly sought by all classes of men, and form the chief, if not the sole diet of thousands, who would otherwise be scantily provided with aliment. But fungi are not only the tolerated food of the poorer classes; they are also highly prized by the rich man and the epicure.

In Italy and Germany immense numbers of the various species of this tribe are sold in the markets, and produce an almost incredible amount of income. It is said that in Rome, so important are the fungi as an article of commerce, there is a public officer appointed to inspect those exposed for sale and superintend this branch of the revenue; for in that mart a tax is laid on quantities exceeding ten pounds weight, which may be offered for sale. All shipments brought to Rome are weighed and sealed up, and those destined for the day's consumption sent to a central depot. If, among the contents of the baskets, any stale, maggot-eaten or dangerous specimens are found, they are sent under escort and thrown into the Tiber. Another remarkable circumstance is the law, that if a specimen of the common mushroom be discovered, it also is to be thrown into the river. Whatever the Romans may say, the latter fungus is a delicious article of food, and very rarely an injurious effect arises from partaking of them.

All those more or less spherical fungi called puff balls, furnished with a membranous, white covering, and filled, when young, with a white, compact, homogeneous pulp, are fit to eat. Personally, the writer prefers them, when in good condition, to mushrooms. Their integument removed, they may be cut in cubes and stewed, or sliced and fried like egg plant. They are of delicate flavor and very nutritious.

For the purpose of benumbing bees, dried puff balls have been burned under hives, while the spoilers rifle them of their hoarded treasure. In former days, as

* Synopsis read before the Delaware County Institute of Science.

* An acid contained in the juice of most fungi. It is said to be a mixture of citric, malic, and phosphoric acids.

† Cellulose moistened with iodine tincture and then treated with strong sulphuric acid assumes a blue color.

‡ According to Schwendener, a lichen is not an individual plant, but rather a community made up of two different kinds of individuals belonging to two distinct classes of cryptogams, viz.: a master fungus and colonies of algal slaves, which it has sought out, caught hold of, and retains in perpetual activity in order to provide it with nourishment.

they will, when old, hold flame for a long time, these fungi were used as tinder, and were often carried in a state of ignition by rustics, for the purpose of lighting their cottage fires.

One more noted species, as yet undiscovered in America, may close our very imperfect account of edible fungi. The truffle is found growing in clusters in clayey or sandy soil some inches under the ground, likewise in chalk, and is common on the Wiltshire downs, as well as in woods both in England and Scotland. The form of truffles is nearly spherical, and their color approaching black. They are studded with pyramidal tubercles, and their spawn is phosphorescent. In England they seldom exceed a few ounces, but on the Continent a weight of several pounds is said to have been attained. As there is above ground no sign by which truffles may be located, discovery is difficult; but so keen have men been in their appetite for this delicacy that they have hit on the plan of having dogs to scent them out. When the animals nose the prize, they stand and whine and scratch on the spot until their masters dig and take possession of the tubers. It is reported that there was known a man capable of exercising this extraordinary function, detecting truffles in the earth by sense of smell.

The expansive growth of fungi may next call for a few remarks. An account has been given of a paving stone, twenty-one inches square and weighing eighty-five pounds, which was raised an inch and a half from its station by a cluster of toadstools growing beneath. Many other facts, that attest the rapid growth of fungi, have been related by different authors. One of these peculiar plants was known in three weeks to reach a girth of seven feet five inches and the weight of thirty-four pounds, and others the weight of twelve pounds in a few days.

But none of these statements, remarkable as they seem, are so wonderful as one made by Sir Joseph Banks, of a circumstance which occurred under his own roof. He avers that a friend having sent him a cask of wine which was too new and sweet for immediate use, it was locked in a cellar to mature. At the end of three years, Sir Joseph, supposing that time had now done its work, proceeded to open the cellar and inspect its contents. Little did he think how nature had been employed, and of the surprise which lay in wait. The door refused to open. Being invincible by gentle means, it was fairly cut away, but entrance was no nearer than before. The cellar was found literally full of fungous growth, which had borne the cask to the ceiling, where it stuck, upheld by fungi, the produce of the wine, which had leaked and formed this monstrous growth.

Another English writer, Dr. Withering, says: "Mr. Stackhouse had repeatedly mentioned to me a large, esculent fungus found on the sea coast in Cornwall, which is, I believe, a monstrous variety of this species. Its whole habit is very large, the button as big as a potato, the expanded pileus (or cap) eighteen inches over, the stem as big as a man's wrist, etc." He also tells of a specimen which weighed fourteen pounds, and was found in an old hotbed.

But huge as this fungus must have been, it by no means equals one grown in Pannonia, and noted by Clusius in his "History of Plants." Of this immense specimen (supposed to have been *Polyporus frondosus*) "after satisfying the cravings of a large, mycophilous household, enough remained to fill a chariot!"

The phosphorescence or luminosity observed in several fungi has given rise to many absurd conjectures. Such a phenomenon depends on the respiration of oxygen, luminosity ceasing when oxygen is unavailable.

The coal mines of Dresden exhibit the interesting circumstance of fungi which emit light like pale moonbeams. A Mr. Gardner states that while passing along the streets of a Brazilian town he "observed some boys amusing themselves with what appeared to be large fireflies, but which proved on inspection to be a fungus belonging to the genus *Agaricus*, which gave out a brilliant, phosphorescent light of a pale green." He next day obtained considerable quantities, and found that a few of them in a dark room gave sufficient light to read.

Concerning a native luminous species, *Clitocybe illudens*, observed by the writer in Lower Providence, but not tested, Charles McIlvaine has this to say:

"Grows in clumps or large masses about stumps or decaying trees, from August to October. Its bright, deep yellow is attractive from a distance. As many as fifty plants may form a cluster.

"The mysterious property of phosphorescence is possessed by this fungus. As heat is known to develop in masses of the fungus, it is of interest to know whether it is from the phosphorescence or a ferment. Its radiance by night surpasses its splendor by day. Mr. H. I. Miller, of Terre Haute, Indiana, first drew the writer's attention to this quality. A large box of specimens sent by him retained their luminous quality after three days of travel to such an extent that the print of a newspaper could be read when held close to the mass.

"Mr. Miller writes: 'There is something about this fungus which generates heat. When I bring in a basketful of it, for the pleasure its phosphorescence affords my friends, I find that after having been in the basket for two or three hours, and while piled one bunch on top of another, that to insert one's hand among the different clusters is like putting it close to a red hot stove.'

"This fungus is so inviting in quantity and beauty that one turns from it with a regret that lingers."

The species in question contains a minor, irritant poison, acting locally on the gastro-intestinal tract, and should not be eaten.

Where in woodland borders there stands a stately toadstool, siren-like, immaculate—beware the tempter, for within that queenly beauty lies the draught of death.

Perhaps if all cases of fatal poisoning by supposed mushrooms were traced to their source, the *Amanita phalloides* would be found to blame. Not less relentless than the Socratean hemlock, its insidious alkaloid stealthily clasps its victim in a grip that scarce knows mercy. The poison of *Amanita* has in some cases been counteracted, in early stages of an attack, by minute hypodermic injections of atropine sulphate.*

"*Amanitæ*," relates Charles McIlvaine, "are the most beautiful and conspicuous of fungi. While there are comparatively few species of them, the individual members are plentiful in appearing from spring until the coming of frost. They are solitary or gregarious in growth. Occasionally two or three are found together. They frequent woods, groves, copse, margins of woods and land recently cleared of trees. They are seldom found in open fields. A careful study of all their botanic points should be the first duty of the student of fungi. Familiarity with every characteristic of the *Amanitæ* will insure against fatal toadstool poisoning, for it is the well-grounded belief of those who have made thorough investigation that, with the exception of *Helvella esculenta*, now *Gyromitra esculenta*, the *Amanitæ*, alone, contain deadly poison.

"They are the aristocrats of fungi. Their noble bearing, their beauty, their power for good or evil, and above all their perfect structure, have placed them first in their realm; and they proudly bear the three badges of their clan and rank—the volva or sheath from which they spring, the kid-like apron encircling their waists, and patch marks of their high birth upon their caps.

"The *Amanitæ* are of all colors, from the brilliant orange of the *Amanita Cæsarea*, the rich scarlet or crimson of *A. muscaria*, to the pure white of the *A. phalloides* in its white form." †

A prominent writer has fittingly observed: "It is exceedingly unfortunate that these deadly poisonous toadstools do not give some warning either in an unpleasant taste or contain an irritant which would act locally to cause emesis and purgation, for in that case the patient would get rid of the poison before such large quantities were absorbed and fatal poisoning would be less frequent. They are not at all unpalatable, and sometimes large quantities are eaten by mistake."

Prof. Charles H. Peck, New York State Botanist, in his Forty-Eighth Report gives the following very explicit directions for distinguishing between the poisonous *Amanita* and the common mushroom:

"Poison Amanita—Gills persistently white. Stem equal to or longer than the diameter of the cap, with a broad, distinct bulb at the base.

"Common Mushroom—Gills pink, becoming blackish-brown. Stem shorter than the diameter of the cap, with no bulb at the base. The mushroom does not grow in the woods."

An extremely poisonous species found in this locality, the fly agaric (*Amanita muscaria*), formerly grew in great luxuriance beneath coniferous trees in Media cemetery. It attains a larger size than *A. phalloides*, and the top of the cap is at first red, turning to orange and becoming paler with age. Warty excrescences, the remnants of the universal veil originally inclosing the young fungus, are also plentiful.

The particular toxic principle of these plants is known as muscarine, a well-known alkaloid isolated by Schmideberg and Koppe in 1869. Its chemical formula has been represented as follows:

$$C_2H_3<\begin{matrix}N(CH_3)_3 . OH\ddagger\\(OH)_2\end{matrix}$$

An enthusiastic mycophagist has described his experience in testing the fly agaric: "A raw piece of the cap, the size of a hazel nut, affects me sensibly if taken on an empty stomach. Dizziness, nausea, exaggeration of vision and pallor result from it. The pulse quickens and is full, and a dreaded pressure affects the breathing. I have not noticed change in the pupil of the eye. Nicotine from smoking a pipe with me abates the symptoms, which entirely disappear in two hours, leaving as a reminiscence a torturing, dull, skull-pervading headache."

* Reported by Dr. J. E. Schadle, Shenandoah, Pa., August, 1885.

† The color of the pileus of *A. phalloides* is quite variable, white and brown being the prevailing effects. A familiar case of color phasing in birds occurs in the screech owl, whose plumage may be red or gray.

‡ Known technically as oxy-choline. It may be prepared synthetically through the oxidation of choline by nitric acid. Small wonder that such a compound plays havoc with the interior.

Small amounts of the dried *Amanita muscaria* are said to be used by inhabitants of northern Asia for the stimulating effect upon the nervous system, producing, like other narcotic poisons, a dreamy state of intoxication, deepening into sleep.

Dr. W. S. Carter, of Galveston, Texas, who has made a careful study of fungal poisoning and its treatment, groups the toxic species in two classes:

First—Those containing minor or irritant poisons, which act locally on the gastro-intestinal tract, such as *Clitocybe illudens* and others. From the prompt way in which vomiting and purging begin there seems to be no doubt of their local irritant action on the alimentary canal. Such symptoms may not be regarded as dangerous unless the poison be taken in enormous quantities or by one in poor health.

Second—Those containing major poisons which act on the nerve centers after absorption, causing symptoms to appear a long time after the poison has been taken and very often terminating fatally. This group includes the various species of *Amanita*. From eating them, vomiting and purging may also happen as prominent symptoms, but generally only occur late—ten to fifteen hours after partaking—and are due to the action of the poison on the nerve centers. This is clear from the fact that these symptoms appear when the poison is given either hypodermically or intravenously to animals.

By means of over one hundred experiments upon lower animals, Dr. Carter has arrived at the following conclusions:

The deleterious principle common to toxic fungi of the second group is muscarine, above named.

Acting upon the nerve ganglia of the heart, a frequent result of its absorption is cardiac inhibition, which may be controlled by atropine.

Owing to the presence of other toxins, life generally ceases in two or three days after poisoning begins.

Toward counteracting late effects, physiological salt solution (0.6 per cent table salt), in conjunction with other remedies, has been recommended.†

The experiments would seem to show that *Amanita phalloides* is much more fatal than *A. muscaria*.

Toadstool poisoning differs from most poisonings in the long time elapsing before death in fatal cases.

No statement can be made as to the cause of this late death, but it would appear to be due to some disturbance of nutrition.

Late death occurs not only in animals, but in most of the cases of poisoning in man recorded in medical literature.

In the case of *Amanita phalloides*, the serious symptoms appear early and continue till the end.

With *Amanita muscaria*, the early effect of the muscarine soon passes off or can be removed by atropine, but the late symptoms still prevail and remain until death.

THE REAL STRUCTURE OF THE UNIVERSE.*

What is the real structure of the stellar world? If we see so many stars in the field, with the telescope directed to the Milky Way, is it because they are really more closely crowded there, as Struve thinks, or is the view of the older Herschel correct, who imagined that the greater richness is simply a consequence of the fact that we are looking in deeper layers of stars; that our universe is more extensive in the Milky Way than it is in other directions?

Imagine that we could actually travel through space. For instance, imagine that first we travel in the direction of the constellation Cassiopeia. If we travel with the velocity of light, not so very many years would pass before we get near to some star. Proceeding on our journey for many, many more years, always straight on, we will pass more stars by and by. How will these stars look thus viewed from a moderate distance—say, from a distance as that of the sun? Will they all be found to be of equal luminosity, as Struve practically assumed? And in this case are they as luminous as our sun, or more so, or less so? Or are they unequal? If so, how many of them are brighter than our sun, how many fainter? Or, to be more particular, how many per cent of the stars are 10, 100, 1,000, etc., times more luminous than our sun? How many are equal to the sun, or 10, 100 times fainter? In a few words: What is the nature of the

* Abstracted from a paper read before the Royal Institution by Prof. J. C. Kapteyn.

† Delobel, in Presse Medicale, September 30, 1899, reports a remarkable case of recovery after the injection of a large amount of normal saline solution. A man, aged fifty-two, ate some *A. Phalloides*. Two full doses of atropine were given hypodermically, as well as 10 cubic centimeters of ether, and 200 cubic centimeters of strong coffee with 20 cubic centimeters of rum were given by the mouth, and hot bottles applied externally. The patient becoming worse, one liter (one quart) of normal saline solution was injected hypodermically. Improvement began in fifteen minutes after the injection, and the patient went to work the next day.

mixture? or, lastly, what is the mixture law of the system of the stars?

Furthermore, in traveling on, shall we find the stars in reality equally thickly, or rather thinly, crowded everywhere? Or shall we find that after a certain time, which may be many centuries, they begin to thin out, as a first warning of an approaching limit of the system? Is there really such a limit, which, once passed, leads us into abysses of void space?

Herschel thought there was such a limit, and even imagined that his big telescope penetrated to that limit; that is, he assumed that his telescope made even the remotest stars visible. On this supposition is based his celebrated disk theory of the system.

Again, we may condense these questions in this single query: How does the crowding of the stars, or the star-density, that is, the number of stars in any determined volume (let us say in a cubic light century), vary with the distance from our solar system?

But there is more. We supposed that our journey went straight on in the direction of Cassiopeia, which is in the Milky Way. What if our journey is directed to the Pleiades, which are at some distance from that belt, or to the Northern Crown, which is still farther, or to the Hair of Berenice, which is farthest of all from the Milky Way? For different regions equally distant from the galaxy we have seen that outward appearances are the same. We may admit, with much probability, that in space, too, we would find little difference. Summing up, the problem of the structure of the stellar system in a first approximation comes to this:

To determine, separately for regions of different galactic latitude, in which way the star-density and the mixture vary with the distance from the solar system.

SCIENCE NOTES.

There are many varieties of insects which are destructive to fruit trees. There are several varieties of insectivorous birds that are natural enemies of injurious insects. Then there are three notorious scoundrels in the bird tribe who are robbers and murderers. They are the English sparrow first of all, the blue jay, and the crow. The wren is worth propitiating, but not every one can build a box for his nest which will admit him and still exclude the sparrow. To overcome the difficulty bore a hole in the box just the size of a quarter of a dollar. It is just the right size.

In some experiments conducted by Harry Snyder, nitrogen, phosphorus, and potassium containing fertilizers, singly and in combination, were applied to wheat, and complete proximate analyses were made of the crop, and a study was made of the influence of the nitrogenous fertilizers upon the amount and form of the nitrogenous matter in the wheat. Milling and technical tests were also made of the wheat, and bread-making tests of the flour. Over forty samples of wheat were included in the investigation. The results show that an increase in nitrogen content of wheat can be secured by the use of nitrogenous fertilizers, but that the additional nitrogen is not all in the form of gluten proteids, a portion of the nitrogen being in the form of amides, nitrates and allied forms. The influence of the fertilizers upon the commercial and bread-making value of the wheat is also briefly discussed. In general an improvement in the quality of the grain was secured by the use of fertilizers.

In 1869 Bunsen wrote to Sir Henry Roscoe an account of a mysterious explosion caused by touching with the finger some reduced rhodium and iridium. The question of the explosive platinum metals has been taken up several times since then by various investigators, but the exact cause of the explosive properties of these metals has not been made clear. The explosive material is obtained by treating the zinc alloy of the platinum metal with an acid, and has been regarded as an allotropic modification of the metal. In the Zeitschrift für physikalische Chemie for February 25 is an interesting account, by E. Cohen and Th. Strengers, of a long series of experiments on this subject. It was found that the residues from the action of hydrochloric acid upon zinc alloys of rhodium, iridium, ruthenium, and platinum are explosive; palladium and osmium do not furnish explosive residues. Explosive rhodium is now shown to contain both oxygen and hydrogen, and if air is carefully excluded during the removal of the zinc by the acid, the residue is not explosive. The heat evolved during the explosion was measured, and found to be of the same order of magnitude as the heat of combination of the quantities of hydrogen and oxygen actually occluded by the metal. The most probable explanation of the explosive properties of these reduced platinum metals is that the explosion is due to the sudden combination of the occluded hydrogen and oxygen. It was found, however, that in the case of ruthenium an explosive material was obtained even if oxygen was rigorously excluded during the separation from zinc, and this point still remains to be cleared up. In one of the calorimetric measurements, 4 grammes of the rhodium destroyed a platinum calorimeter. A photograph of the remains of the calorimeter after the operation is given, and the authors remark that the effect of the explosion of a pound of this material (the quantity Bunsen had in the experiment above mentioned) can be easily imagined. Bunsen, fortunately, escaped with superficial burns on the face and severe burns on the hands.

ENGINEERING NOTES.

In a paper read recently before the Verein deutsch. Eisenhüttenleute, Düsseldorf, by A. Haarmann, an outline of the evolution of sleepers is given, with German statistics, from 1898-1905. It is estimated that the cost per kilometer of iron sleepers and the necessary fastenings is 311.00 marks, as compared with 575.83 marks for wooden sleepers and fastenings; in each case allowance has been made for value of worn-out material. The author gives technical arguments strongly favoring the adoption of iron sleepers.

A high rate of progress was attained in the headings of the Loetschberg Tunnel, Switzerland, during April, 1908. The advance of the south heading during that month—twenty-eight working days—is within 5 per cent of the record established in the Simplon Tunnel, when 685.5 feet was driven in a single heading in one month. The Loetschberg figures for April are 656 feet for the north heading and 521½ feet for the south heading, a total of 1,177½ feet. The two headings have now penetrated respectively 6,986 feet and 5,658 feet into the mountain, a total of 12,644 feet.

The Postmaster General has appointed a committee consisting of Samuel M. Gaines and Charles Rager, superintendents of railway mail service; H. M. Robinson and H. McC. Wade, assistant superintendents of railway mail service, and B. L. Andrus, superintendent of the mail lock repair shop, to test a number of devices intended for exchanging mails with moving trains, without throwing the bags on the ground. In response to an advertisement issued in October last, proposals relative to 76 catching and delivering devices were received by the postmaster general. These proposals were publicly opened January 15. Preliminary tests having been made of such devices as were submitted, it is now found that eight of them are worthy of further consideration. It is the purpose of the committee of expert officials to make a thorough test of these eight devices and to report to the postmaster general as to the practical workings of each of them, with a view to the adoption of one of more by the department.

A steel rising main, 2,355 feet in length, is under construction in a new shaft of the Newport Mining Company, of Ironwood, Mich., for the drainage of workings some 2,000 feet below the surface. This company recently struck, after two years of drilling, a valuable mineral deposit at this depth, and a shaft has been sunk at an angle of 68 deg., having been calculated to meet the deposit which was discovered by vertical drilling. The rising main, which is of 8-inch steel pipe, is being put down in ½ inch thickness for the lower half and ⅜ inch for the upper half, and is fitted with flanged joints every 200 feet and screwed joints with heavy recessed couplings between. To provide for expansion from temperature changes, three heavy cast steel expansion joints are used. The fittings, valves, and other steel parts used in the line are the heaviest that have been turned out of this company's steel foundries. The line is said to be the longest pump column ever used for pumping direct to the surface without relaying, being nearly one-half mile in length.

In the Zeitschrift für Bauwesen, the harbor engineer of Kiel gives details concerning the vertical movements which have been observed in the two concrete drydocks at that port. Those structures are built of concrete, and lie side by side at the distance of 75 feet apart, the side walls being about 18 feet thick at the base, and the bottom 18 feet thick. Each dock chamber has the effective length of 574 feet, the width of 98.4 feet at the entrance, and the normal depth of water 36.4 feet. The foundations rest upon a deep stratum of fine sand. It has been ascertained by careful measurements that when either chamber is filled with water the bottom bends downward from 0.24 inch to 0.79 inch, and that when either chamber is pumped dry a corresponding upward bend takes place. The weight of a 14,000-ton battleship causes practically the same amount of bending as the entire charge of water. According to the report of the harbor engineer the distortion is due not to the bending of the dock bottom as a whole, but to the movement of the surface layer, 16 inches thick, which was laid independently of the concrete below and permits the access of spring water. The result seems to be that the upward bending of the surface is effected by hydrostatic pressure when the dock is empty and that downward bending takes place when the same pressure is counterbalanced by the weight of water or of a ship resting on the bottom. Another series of observations revealed the fact that the entire dock structure settles downward when full of water and rises when emptied. The vertical movements are small, being nowhere greater than 0.2 in., but they certainly throw interesting light on the behavior of compressible soil under load.

TRADE NOTES AND FORMULÆ.

Artificial Kumys.—1,100 parts of soda water, impregnated at 6 to 8 atmospheres with carbonic acid, 100 parts of condensed milk, 1 part lactic acid, 0.5 parts of citric acid and 15 parts of cognac.

Hard Sole Polishing Wax.—25 parts of paraffine (50/52 deg.), 12 parts carnauba wax, fat grey, 2 parts Venice talc. The paraffine and carnauba wax are melted together and colored yellow with a small quantity of yellow aniline color, soluble in fat, the talcum being then stirred into this mixture. It is allowed to cool off somewhat and it is then quickly poured into molds. Cone-shaped tin molds are best for the purpose, as in this form the wax is most convenient to handle.—Der Chemisch-Technische Fabrikant.

Cleansing the Floors in Factories and Workshops.—The dust and sweepings that accumulate in the workshops of industrial establishments using the precious metals, contain, it is well known, a large quantity of precious metal particles, which they must endeavor to recover. For this purpose, such apartments are sprinkled with moistened sawdust, which holds the sweeps better; it is then further treated, which is best effected in an establishment specially equipped for the treatment of sweeps. The sweeps are then heated to redness, ground, examined for possible lost precious stones, iron particles removed with a magnet and the whole then washed and smelted.

To Remove Ink Spots from Copper Plate Prints.—Paint the spots with a brush dipped in chloride of lime solution until the black spot turns a rusty brown. Then wash with water, next put pulverized oxalic acid on the spot. Now, with another brush put a few drops of hydrochloric acid on the oxalic acid. The rusty spot turns yellow and can be removed by washing with water. Grease spots: If on the border or back, paint with oil of turpentine and press between blotting paper, repeating the operation several times; lay the print on a paper on which dry hot powdered plaster has been sprinkled and spread the same on the upper surface of the spot. Finally moisten and press the spot.

To Bleach Copper Plate Engravings.—Stir 0.5 part of chloride of lime with 2 parts of water, add 8 parts more water, stir the fluid during 2 hours five or six times, allow it to settle and pour off the clear fluid, dilute with 3 parts of clean water. Lay the copper plate print between two frames, covered with linen, then in a box pour the chloride of lime solution over it and leave it standing from half an hour to an hour. Allow the fluid to run out at the bottom of the box, pour in clean water several times, take out both frames, dry partially, remove upper frame and press the print between cardboard sheets.

Artificial Wine (Sweet Wine).—20 parts of sweet wine consisting of: I. 3 parts of rectified wine spirit (96 per cent) perfectly free from fusel oil; 5 parts of sour wine, also fruit wine; 3 parts of sugar boiled in 4 parts of pure water, and skimmed; remainder (up to 20 parts) water. II. 3 parts of rectified spirit (96 per cent), as above, 4 parts of wine, 2.5 parts of sugar, remainder (up to 20 parts) water. III. 3 parts of rectified spirit (96 per cent), 3 parts of wine; 2 parts sugar, remainder to 20 parts, water. According to taste add to this wine muscatel, malaga, madeira or other essence, in the proportion of about 0.001 part. Sweet wine without essence: I. 3.25 parts of rectified spirit (96 per cent), 6 parts of white wine, 3.2 parts of sugar, 2 parts of port, malaga or madeira wine, remainder to 20 parts, water. II. 3.25 parts of rectified spirit (96 per cent), 7 parts of white wine, 4.2 parts of sugar, 3 parts of port wine, malaga, etc., remainder to 20 parts, water. Perfectly pure water, spirit free from fusel oil and well-skimmed sugar syrup must be used.

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